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LUCERNE: ITS ECOLOGICAL POSITION AND DISTRIBUTION IN THE WORLD.

ABERYSTWYTH, NOVEMBER, 1933.

IMPERIAL BUREAU OF PLANT GENETICS: HERBAGE PLANTS

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LUCERNE: ITS ECOLOGICAL POSITION AND DISTRIBUTION IN THE WORLD.

By

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INTRODUCTORY NOTE.

It was decided to translate and publish as a Bulletin the material collected by Dr. M. Klinkowski on the ecological distribution of lucerne types, as it was considered that such a publication would serve for the general agricultural reader as a survey of the spread of this most important forage crop throughout the world, while the reader interested more particularly in the crop itself would be introduced to an extensive bibliography on many aspects of the question. The original text has been very considerably reduced for reasons of economy without, it is hoped, detracting from the value of the material.

This publication is especially opportune at the present time. Firstly, because of the international test of geographical types of lucerne which has been organized by the Herbage Bureau in many parts of the world, and which will be described in the December (1933) number of *Herbage Reviews*. Secondly, because of the importance attached to the study of world collections of agricultural plants by the plant breeders of the Soviet Union, under the direction of Professor N. I. Vavilov, as will be seen from a perusal of a Bulletin (No. 13 from this Bureau) on the research programme of the Institute of Plant Industry, Leningrad, to be published conjointly by the Imperial Bureaux of Plant Genetics, Aberystwyth and Cambridge.

An index is appended as a guide to the more important references made in the text to strains of lucerne (whether of *Medicago sativa*, *M. falcata* or their hybrids) and to other species of *Medicago* which are mentioned.

R. O. WHYTE.

Names of Corresponding Editors and details of Herbage Publication Series at end of Bulletin.

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LUCERNE: ITS ECOLOGICAL POSITION AND DISTRIBUTION IN THE WORLD.

COUNTRY OF ORIGIN.

Medicago sativa L. is a native of the temperate regions of Western Asia, Media, the countries south-east of the Caucasian Range and the north-western part of modern Persia. It is the oldest forage plant known and was mentioned in the Old Testament, for Nebuchadnezzar sent Daniel to obtain lucerne seed. It is not possible at the present day to indicate a more limited area for its origin. Lucerne comes from steppe districts, such as the " hunger steppes " of Turkestan, with a pronounced continental climate. A late spring and a short, hot summer characterize these arid regions, the flora of which is composed almost exclusively of halophytes. In this connection it is interesting to note that in these regions the B gene in human beings, as studied in the Turkoman group, is strikingly concentrated.[1] The soil is composed of brown and grey earths originally derived from Aeolian loess. These very finely grained soils are unusually rich in water-soluble sodium salts. The salts frequently form an efflorescence upon the surface, so that other crop plants cannot exist. In the " hunger steppes " of the Turanian plateau lucerne thrives to the present day on saline soil which has proved unsuitable for any other crop.[2] In a moist and foggy climate lucerne has little persistence. For this reason it seems inadvisable to cultivate it in the northern coastal lands, where it succumbs to the competition of the more hygrophilous grasses after two or three years. The reasons governing its appearance in Scandinavian countries as far north as 59° lat. must be the subject of closer investigation. In England, where the rainfall is so high, the growing of lucerne has never attained any great importance. The wet summers prevalent in this country are an obstacle to permanent lucerne cultivation, although it comes into favour again with English farmers in dry years.[3]

MIGRATION.

The triumphal progress of the queen of forage plants, as it has been called, stretches far into the pre-Christian era, and follows in the path of the historic civilisations from East to West. It reached Greece about 470 B.C. during the campaigns of the Persian King Darius, having already spread over the south-eastern shores of the Caspian Sea and Turan. It is first mentioned in literature by Aristophanes and Aristotle.[4]

Not until nearly three hundred years later did it reach Italy from Greece (150 - 200 B.C.), where its cultivation at that time became widespread. About the same time it obtained a foothold in North Africa, where it is still found at the present day as a valuable forage plant in the oases.

It is not yet clear whether it was brought from Italy to North Africa by the Romans, or whether it came direct from Asia. In Asia lucerne followed the old caravan roads as far as China. In Europe it was limited for centuries to the two Mediterranean countries, and in North Africa was confined to the oases. It is true that it is reputed to have reached the south of France from Italy, but its cultivation here died out within a short time, and not until the thirteenth century was there an increase in the area of its cultivation. When the Moors invaded Spain they brought with them the forage plant which they valued so highly and named " alfalfa" (" the best fodder "), and from Spain it set out upon its triumphal progress throughout the whole world.

At the beginning of the sixteenth century it was taken by the Spaniards to Mexico and soon became distributed over Peru and Chile, whence it obtained a firm footing in Argentina and Uruguay. Its distribution was, however, confined at first to Central and South America.

In Europe it spread from Spain to France about 1550, reaching Belgium in 1565, and, under the name of " Bourgoens hoy," Holland. It is improbable that lucerne reached France by way

of Northern Italy, as is stated by Schlechtendahl.[5] Five years later it had penetrated as far as the Mainz district and the Rhenish Palatinate, although at that time it appeared to be valued there as a garden plant only. In 1587 it was found in the Lausitz district under the name of "Burgundy hay," and in the same year it reached Hungary also (probably from Italy). Its cultivation in Hungary, however, became extinct during the Thirty Years War, and was introduced again only towards the end of the eighteenth century. The black soil region of Russia was reached not, as one would assume, from the west Asiatic steppe district, but by way of Spain and France.

Authoritative sources first report the cultivation of lucerne in Germany as a field crop about the year 1710, in the province of Thuringia. Its introduction into Franconia met with great opposition on the part of the local farmers, but by degrees they learnt to appreciate its value and importance. At the present day lucerne occupies more than 8 per cent of the total area of shell limestone soil. The rate of expansion of "Old Franconian hybrid lucerne" was quite extraordinary.

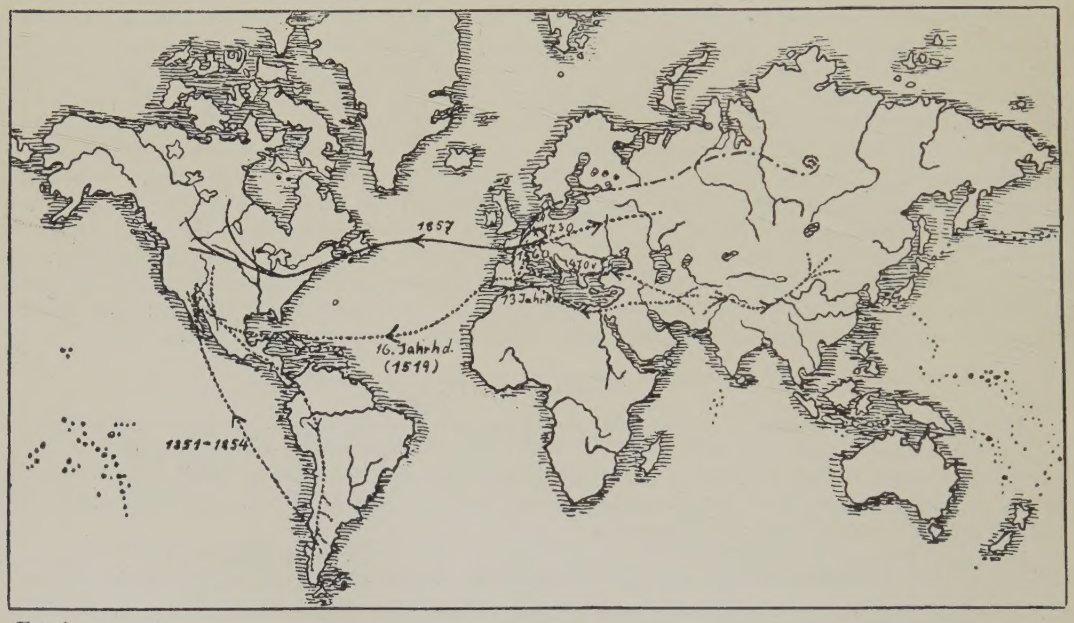


FIG 1.

. . . . . The migration of *Medicago sativa*.
— . — . — The probable path of *Medicago falcata*.
———— The migration of the Franconian hybrid lucerne (*Medicago media*).

Whilst lucerne cultivation had attained great importance in South America as early as the eighteenth century, it was completely unknown in North America until it arrived in the middle of the nineteenth century by two different routes. Gold seekers introduced "Chilean clover" from Chile to California in the years 1851-1854, and only a few years later it reached Colorado from Mexico. Climatic conditions (intense cold during the winter months) set a boundary to the northward penetration of this strain. Lucerne cultivation would never have reached its present position of importance in North America had not the hybrid lucerne form been introduced into the United States and Canada. A German farmer, Wendelin Grimm, brought seed of the Franconian hybrid lucerne from Germany in 1857 to his new home in Minnesota. From this small quantity of seed has emanated the "Grimm lucerne" which to-day occupies wide expanses of the country and is held in particularly high esteem.

Summarizing the principal features of this migration in chronological order, the following review is obtained :

Media, north-western part of modern Persia ; the home of lucerne.	
Media→south-eastern shores of the Caspian Sea→Turan.	
Persia→Greece	470 B.C.
Greece→Italy	150—200 B.C.
North Africa (from Italy or direct from Asia)	150—200 B.C.
Media→China.	
North Africa→Spain	13th century A.D.
Italy→Provence.	
The vicinity of Soissons	1516
Spain→Mexico	16th century.
Spain→France (according to Schlechtendahl, Northern Italy→France)	1550
France→Belgium (Malines)→Holland	1565
Rhenish Palatinate→Mainz	1570
The south of France→Switzerland.	
Geneva	16th century.
Hungary	1587
Lausitz	1587
England	about 1650
Austria	about 1700
Ebrach in Franconia (from France)	about 1710
Stotternheim, near Erfurt (first place in Central Germany for lucerne to be cultivated)	1730
North Germany	about 1750
Spain→France→Russia.	
Northern Switzerland	18th century.
Zürich	1746
Argentina→Uruguay	1775
Vicinity of Stockholm	1770—1780
New York State	1820
Tibet→Russia	1847
South of France→Union of South Africa	about 1850
Chile→California	1851—1854
Külsheim, Baden→Minnesota	1857
Mexico→Colorado	1862
California→Utah.	
Utah→Colorado	1886
Bulgaria	about 1890
Colorado→Kansas	1894

DISTRIBUTION IN GENERAL.

If the present world distribution of cultivated lucerne is studied, it is seen that the crop is concentrated more particularly in certain zones, namely, in the northern hemisphere, the United States of America, Canada, the south of France, Northern Italy and the cultivated part of Turania, and in the southern hemisphere, the Argentine Republic and some parts of Chile. Its greatest concentration is to be found in America ; the Argentine Republic, the United States and Canada together comprising the most important of all lucerne areas. There is a perceptible diminution of cultivation as the subarctic or the subtropical zones are approached. Lucerne is a forage crop of temperate zones, as is indeed indicated by its origin. Occasionally, it is true, it has been cultivated in tropical countries also, but without entirely fulfilling expectations. The climatic conditions of the tropics result in a disturbance of the plant's physiological constitution, and after two years' cultivation, often indeed in one year only, the crop dies back.

The following figures for some of the lucerne growing areas serve to indicate the importance of this forage plant.[6, 7, 8]

Lucerne areas in acres.

	1926.	1929.
Argentine Republic	19,574,392	14,424,800
United States of America	11,339,083	
France	2,821,503	2,816,047

Lucerne areas in acres.—(*Continued*).

	1926.		1929.	
Italy	approx. 1,482,000			
Canada	898,845		798,598	
Germany	671,424		704,626	
Russia	494,000	approx.	642,200	
Hungary	433,930		374,294	
Czechoslovakia			262,224	
Rumania	253,930		372,180	
Union of South Africa	187,026		188,520	
Spain	185,865		190,701	
Australia	17,050			
Yugoslavia	13,288		159,430	
Chile	13,204			
Mexico	11,718		117,184	(1928)
Brazil			86,450	
Denmark	79,203		37,544	
England	46,955		35,768	
Belgium	29,852		23,284	
New Zealand			30,815	
Switzerland			28,106	
Bulgaria	23,877		23,877	
Sweden	19,019			
Luxemburg			13,434	
Uruguay	12,436			
Holland	7,945		6,350	
Algiers	5,992		6,625	(1928)
Austria	4,238 ?		96,532	
Poland	3,013			

We will next proceed to trace the cultivation of lucerne in an eastward direction, starting from Central Europe.

DISTRIBUTION IN PARTICULAR COUNTRIES.

GERMANY.

During the last fifty years the area devoted to lucerne cultivation in Germany has increased by approximately 19 per cent only, whereas the increase in the Argentine Republic, for example, certainly under quite different conditions, amounted to almost 1000 per cent. Although it is not possible to draw a parallel between these figures, yet they show that a conservatism of thought rules where the cultivation of lucerne is concerned, and that in the main it continues to be grown only in those districts in which it has always been valued. Certain dislocations have taken place within the lucerne cultivation centres in Germany, without the total result being materially affected thereby. The following is a summary of the position during the last fifty years.[9]:

	Acres.
1878	571,805
1883	468,065
1889	514,500
1900	558,940
1913	515,000
1929	704,700

The greatest concentration of the crop is in Lower Franconia and the neighbouring districts of Baden.

The shell limestone and the climate of this region (dry heat type) guarantee its success. The largest area is in Baden, where in certain districts it occupies one-third of the arable land. In other districts, including the plain of Baden, the ratio varies from 17 to 25 per cent. In the rain shadow of the Hochvogesen, with its lack of precipitation and heat in summer, lucerne is one of the most common forage crops. In the vineyard district it is also of great importance, varying from 15-22 per cent of the arable land. In the hilly regions of Nassau, in the Westerwald, the Sauerland spurs and in the Tanus Mountain district lucerne could not be established on

account of the deficiency of lime.[10] Noteworthy is the wide extent to which lucerne is cultivated on the volcanic soil of the Bitburg district in the Eifel (25 per cent of the cultivated area).[11] The date at which this crop was introduced into the Eifel cannot be exactly ascertained. In the eighteenth century it was grown in all parts of the Eifel and in the district of Trier, but apparently to a limited extent only, which may probably be attributable to the fact that it was unsuitable for the cropping system of those days. At the time of Napoleon's occupation of the Rhineland the growing of lucerne and also of sainfoin received an impetus. The lucerne grown in the Eifel to-day is certainly a hybrid lucerne, as is clearly shown by the flower colour, which includes different blue types and occasional yellow segregations. The Eifel lucerne has a very branched habit, a character considered to be of great advantage in providing tender and leafy forage. The Bitburg district is the centre of lucerne cultivation in the Eifel. The seed of this local lucerne is described as " native seed " to distinguish it from commercial seed, which generally consists of Provence lucerne ; the former is sold for three or four times the price of commercial seed. The typical soils on which lucerne is grown in the Eifel consist of Keuper lime, and in part of Devonian. The climate is for the most part rather severe, with relatively high rainfall. Lucerne is generally sown under another crop. The younger stands are preferred for seed production. Since the War there have been endeavours to promote lucerne seed production in the Eifel, and a society has been founded for this purpose, but little has yet been accomplished. The Rhenish Department of Agriculture has also shown great interest in the matter and for several years has been engaged in selection work.[12]

FIG. 2. LUCERNE AREA IN GERMANY, 1929 (from the returns of the Government Statistical Office).
Crosshatching .. 0.8—3.1 per cent of total cultivated area.
Black .. .. 3.1—7.0 per cent of total cultivated area.
White crosses on black ground .. more than 7. 0 per cent of total cultivated area.

The cultivation of lucerne is of great economic importance in Thuringia, where the crop has long been grown, and there should be mentioned also the Bavarian Palatinate, certain parts of Württemberg, parts of Hessen, and the Free State of Anhalt and the Province of Saxony. Individual areas of considerable extent are to be found even in the North of the country, for instance in the Uckermark and the neighbouring part of Pomerania ; in Eastern Germany also isolated areas of some size are found.

The historical development of German lucerne cultivation may best be traced in Bavaria, where it was introduced about 1710 by the Cistercian monks of the Ebrach Monastery in Franconia. It is generally thought to-day that the monks brought the lucerne with them from France[13], but it is quite possible that the first seeds were obtained from fellow Cistercians in the Rhineland, who had probably introduced it from France at a much earlier date. At first the monks do not seem to have been successful with *Medicago sativa*, which was the species cultivated. It is not difficult to grow this variety on the shell limestone, but it is of short duration here, whilst it is always unreliable on the Keuper soils.[14] Only from 1730 onwards was success obtained in the growing of lucerne in this district. This increasing success probably runs parallel with the increasing hybridization of *Medicago sativa* with the form of *M. falcata* growing wild in the same district. The cultivation of the new forage plant remained confined to the Ebrach district for a few years only; in spite of a general resistance on the part of farmers, and of many set-backs, lucerne gained the day, and it is now a valuable component of the country's agricultural flora. Von Dungern[15] attributes to Franconia in the eighteenth century a preponderance of lucerne crops: "So much is certain to-day, that the Franconian Keuper soils are very unproductive when there is little or no lucerne, for it is only lucerne, combined with heavy stable manuring, that will bring the necessary activity into these dead soils." Not only in Lower Franconia, but also in the neighbouring districts of Central Franconia on the north west, much lucerne has been grown for centuries, principally on loess and shell lime, more rarely on gypseous Keuper soil.[16] The chief lucerne districts lie in the neighbourhood of Würzburg, Ochsenfurt, Uffenheim, Karlstadt, Schweinfurt and Kitzingen. The importance of lucerne here is shown by the fact that the proportion of meadowland is very low, varying from 3 to 8 per cent of the total cultivated area.

In the principal lucerne growing area is found also Germany's principal lucerne seed production area, producing the "Old Franconian lucerne." This region, which divides into two overlapping parts, includes on the Bavarian side parts of Geretzhofen, Hassfurt, Gmünden, Hammelburg, Scheinfeld, Lohr and Marktheidenfeld in addition to the districts already mentioned. These localities form part of the driest districts of Bavaria; Schweinfurt, for instance, has an average annual rainfall of 514 mm., Uffenheim 556 mm., and Würzburg 558 mm. The mean annual rainfall thus varies from 500 to 600 mm., and in unusually dry years falls to from 270 to 400 mm. The Bavarian seed production area falls into three divisions: Tauberbischofsheim with the districts of the Taubergrund and the Nebentäler, Boxberg with the Umpfergrund and Schüpfergrund localities, and Krautheim with the Jagstgrund villages.[1]

The total increase of the lucerne areas in Bavaria from 1913 to 1929 amounted to approximately 25 per cent, and thus runs parallel with the total area increase for Germany. In the various Bavarian districts the percentage of the agricultural area under lucerne was as follows:[18]

	1913.	1929.
Upper Bavaria	0.1	0.17
Lower Bavaria	0.1	0.22
The Palatinate	3.0	3.9
The Upper Palatinate	0.1	0.25
Upper Franconia	0.5	1.05
Central Franconia	1.8	2.32
Lower Franconia	5.8	7.17
Swabia	0.3	0.47

The high rainfall of the southern and eastern zones of this country, together with the very sour soils of Eastern Bavaria[19] explain the small extent to which lucerne is grown there. Apart from the shell limestone, good lucerne stands are found on the deep loess soils, even in pure sand, as on the Estate of Triesdorf where a lucerne area on light Keuper sand was used for twelve years with the greatest success.[20] On soil of this nature lucerne is not so persistent as on the dry limestone. Lochner[21] reports from Lower Franconia the existence of slopes upon which the lucerne is said to be more than 50 years old.

The seed of the Old Franconian lucerne is comparatively small-grained and may therefore be easily distinguished from seed from Italy and the south of France.[22] Characteristic also is the

high percentage of hard seed. Hiltner[23] commends in the Old Franconian lucerne not only its longevity, winterhardiness, and consistently good yield, but also its disease-resistant properties. It is said to be less susceptible to the root parasite *Rhizoctonia violacea* Tul., for example, than other varieties. For a number of years more intensive breeding of Old Franconian lucerne has been carried out, the most important breeding station being in Neuherberg, where lucerne is found on every farm.[24] If the lucerne introduced by the Cistercian monks in 1710 belonged to the *Medicago sativa* group, the present Old Franconian lucerne is definitely a hybrid. Formerly the Iphofen lucerne, a form of the Old Franconian, was referred to as a pure *M. sativa* form.[25] On a tour in the summer of 1931 I ascertained, however, that the Iphofen form also has been crossed with *Medicago falcata*, although the proportion of *M. falcata* is less than in the other Old Franconian forms. A great variety of types is found, leafy and poor in leaves; abundantly flowering types and types with few flowers; tall, long-stemmed or quite bushy types; creeping types; late and early-flowering; forms with closely and widely spaced internodes; and types with the greatest variety of leaf shapes. Leaf colour also varies within certain limits, quite light-coloured examples being relatively frequent.[26] The colouring of the Old Franconian lucerne is very variable and corresponds to the proportion of the two parent lines present. Even in Franconia *Medicago sativa* would have been limited to a certain area if increasing hybridization with *M. falcata* had not enabled it to invade the Keuper soils also. Whereas formerly it was the *M. falcata* proportion of the Old Franconian lucerne which was constantly on the increase, at the present day the movement is in the opposite direction, as has been shown elsewhere.[27] The more the *M. sativa* characters predominate, the less becomes the winterhardiness and the shorter therefore the life of the lucerne. The subsoil, moreover, is less advantageously utilized, because the *M. sativa* type has less branched roots.[28, 29] The hay quality is certainly better, but the quantity is less. The most important property of the Old Franconian lucerne is its great adaptability to ecological conditions—our first duty should be to maintain this character.

Thuringia must be regarded as the oldest centre of lucerne cultivation in Germany, Stotternheim in the neighbourhood of Erfurt being one of the first places in the country where lucerne was grown. Two centuries have elapsed since the Stotternheim lucerne[30] spread over the rest of Thuringia, where it occupies to-day almost 59,280 acres, or approximately 3.6 per cent of the cultivated area. The widest distribution according to Paulssen[31] is in the Weimar district, in a narrow zone of the Gotha district, in the Sondershausen district and south of the Thuringian Forest in the Hildburghausen district, a distribution which is explained by the geological formation of Thuringia. On the Keuper, shell limestone and Permian formations lucerne has a predominant position, whereas it is of little importance upon the variegated sandstone formation of which large areas of the country are composed. As in Lower Franconia, the best seed is obtained in vineyard localities, the light soils taking a second place. Thuringia's chief lucerne seed production district is situated in the northern part of the Weimar district, the geological formation of which belongs to the fertile Keuper basin of the lowland. In many cases, however, the Keuper strata are covered with diluvial and alluvial deposits. In this district about 435 acres are devoted to the seed production of " the blue-flowering Stotternheim lucerne," as the Thuringian lucerne was formerly called. The Wichmar area, situated on shell limestone north of Weimar, is of local importance only.

There are no seed production areas of importance in Germany other than those already mentioned in Bavaria, Baden, in the Eifel and Thuringia. Only in Lower Franconia and the adjacent parts of Baden is there any superfluity of seed, and even this is quite insufficient to fulfil the requirements of Germany. In 1928, according to the estimate of German seedsmen, 122,820 bushels lucerne seed were imported, at a cost of RM. 557,200.

CZECHOSLOVAKIA.

As long ago as the seventeenth century the cultivation of lucerne was known in Czechoslovakia, although it did not become generally distributed until a much later date. The best lucerne districts are situated on deep loam and clay soils rich in lime, having a sufficiently deep water table. Light, sandy soils are rarely used for lucerne, although one occasionally finds the Bohemian sand lucerne on this kind of soil in the plains of the Elbe. Three indigenous,

propense varieties are grown in Czechoslovakia : in Moravia a form called " Moravian lucerne," in the Plains of the Elbe the sand lucerne already mentioned, and in Slovakia the " Slovakian lucerne." No breeding of these forms has as yet taken place, but recently work has been initiated in Slovakia (Slovenský Meděr). The indigenous varieties were submitted to certain tests in the first place ; their characteristics are high and reliable yield, good rooting, longevity and winterhardiness, and also, in suitable climatic conditions, satisfactory seed yield. Of foreign varieties only Provence, Italian and Hungarian lucernes are grown. All seed sold by seedsmen and co-operative societies for sowing has to be sealed by the Seed Control Stations. The re-

FIG. 3. LUCERNE DISTRIBUTION IN CZECHOSLOVAKIA (after Chmelar).
+ Principal lucerne districts.
— Cultivation worthy of note.

quisites for this purpose are freedom from *Cuscuta* and normal quality (97 per cent purity and 88 per cent germinability). Imported seed is examined at the frontier and also has to be sealed. The bags have to be plainly labelled with a description of the variety and place of origin. Lucerne is sown down either without a cover crop in spring or after the harvesting of the summer cereal crop. In addition to the usual potash, phosphorus and lime dressings, stable manure, which serves also as a protection against frost, is applied in winter in high localities.[34]

AUSTRIA.

Tyrol.

Lucerne (of Provence origin) is grown in this province principally in those mild localities where maize will ripen. The chief limiting factors are the elevation and the severe weather conditions experienced in certain parts. Where, however, districts are under the influence of the Föhn winds (warm, dry winds blowing from the mountains to the lowlands) or are protected from the north by high mountains, lucerne is a reliable crop, provided the soil is not too heavy and the water table is not high. The crop in certain favourable districts reaches a height of 1000—1200 m., but where less favourable conditions prevail it does not pass much beyond 800 m. At the limits of its successful cultivation it is grown in combination with *Dactylis glomerata, Avena elatior, A. flavescens* or *Onobrychis sativa.*

Little success has been achieved with the seed production of this crop in the Tyrol, as the seed rarely ripens. Generally the pods drop early, owing to the high rainfall in June and July.

In the winters of 1922-23 and 1923-24, lucerne tolerated a covering of snow of from 50 to 80 cm. An indication of the favourable distribution of the rainfall in the Tyrol is the fact that lucerne gives an abundant stubble crop nearly every year, frequently reaching a height of 30 cm. in the first autumn. In unfavourable localities it is of the greatest importance that lucerne should enter upon the winter in a vigorous state, for which reason it is customary to cut the cover crop (oats or barley) green. In the neighbourhood of Innsbruck, in spite of the quantity of snow which often falls in winter, an autumn sowing of lucerne on winter stubble, ploughed up early, is the common practice.

In the Upper Inntal (valley of the River Inn), lucerne has a duration of from six to ten years when properly manured, even in soil with a weathered rock subsoil, and still longer in lime soils ; it gives three cuts regularly even in the higher localities.

Vorarlberg.

Here lucerne had many adherents about fifty years ago, but in the last three decades it disappeared almost entirely from cultivation. Only since 1921 has it assumed proportions which are satisfactory when the Vorarlberg soils are taken into consideration. Since that date approximately 100 bushels of seed of Italian origin have been sown down. In the higher localities its cultivation has been unsuccessful, not, however, for climatic or meteorological reasons, but because the lime content of the soil is almost everywhere inadequate. Most of the newly sown down fields are to be found at a height of from 400 to 600 m. Lucerne is never sown in pure stands, but always in a mixture with *Dactylis glomerata* and *Avena elatior* (85 per cent lucerne, 10 per cent *Dactylis* and 5 per cent *Avena elatior*).

Kärnten.

Lucerne is grown fairly extensively in the dry regions of Lower Kärnten and succeeds up to a height of 700 m. Geologically speaking, its cultivation covers the region of the Klagenfurt basin.

FIG. 4. LUCERNE DISTRIBUTION IN AUSTRIA. (according to Sander).

Steiermark.

Lucerne is grown in the middle Ennstal on the slopes of the northern limestone alps just as in the Inntal, Tyrol, and combined, as in the Tyrol, with *Dactylis glomerata* and *Avena flavescens*. The quantity of seed sown is 30 kg. lucerne, 3 to 5 kg. *Dactylis glomerata* and 1 kg. *Avena flavescens* per hectare. Nowhere in the Steiermark does the crop reach the heights it attains in the Tyrol, probably because of the absence of the Föhn, nor are the Tyrolean upper limits approached in any of the other Austrian alpine districts.[35]

Upper Austria.

The cultivation of lucerne in most districts is very limited, as the requisite permeable subsoil is lacking and the ground is too heavy. Only in the district between Linz and Wels, in the so-called Wels Heath, where there is a humus soil with a considerable amount of weathered limestone and a precipitation of 400 to 600 mm., is much lucerne grown, because red clover here suffers from the drought. In this region the seed also ripens, but is seldom harvested. The harvest returns (which unfortunately are not very reliable) show for Upper Austria a lucerne area of 470 acres, for Lower Austria 75,600 acres, and for Burgenland 10,890 acres.

Lower Austria.

The greatest extension of lucerne cultivation is found in this province, where meadows, pastures and forage crop production occupy 26 per cent of the total cultivated area. In the mountain districts, with their high rainfall and soils rich in lime and humus, meadows and pastures take the foremost place. In the flat land forage crop production, and with it the growing of lucerne, are prominent. Lucerne growing is concentrated in the warmer parts of the country, particularly on the small vine-growing farms. In the forest district, on the other hand, clover is the preferred crop.[36]

Burgenland.

The climate and soil are here on the whole very suitable for lucerne cultivation. The crop grows well, giving three or four abundant cuts in most parts, with the exception of a few places with unsuitable soil, and the afforested district. In the north it is grown mostly in pure stands, while in the central and southern parts of Burgenland, where the rainfall is considerably greater (about 770 mm.), it is grown in a mixture with grass. The seed used is for the most part home-grown or Provence lucerne, the latter having proved useful in these districts on account of its winterhardiness. Lucerne of Italian origin cannot resist the intense cold and in most cases dies back in winter. As lucerne has been found to be the most reliable and profitable forage crop, it has become widely distributed, to the extent of 2.38 per cent of the total arable land area in 1929.[37]

SWITZERLAND.

Lucerne was probably introduced into Switzerland from the south of France.[38] In no other country does forage crop production occupy so important a position ; according to Volkart 90 per cent of the total area is devoted entirely to forage crops, half of which consists of natural meadows, mostly at great heights. Of the remainder, four-fifths are occupied by pastures, whilst the rest is divided between clover-grass, lucerne and red clover.[39] Switzerland offers a good illustration of the power of lucerne to tolerate a high degree of cold and long periods of snow. It is found in Switzerland up to a height of 1300 m., even in districts with extremely unfavourable climatic conditions. The inhabitants of these districts say that " for nine months here it is winter and for three months it is cold." [40] In the Lower Engadine lucerne is widely grown as the sole forage plant, giving two and at times three good cuts. It is even reported by Stebler that in one case lucerne was grown as a field crop at a height of 1541 metres. In the Canton of Graubünden lucerne fields 20 to 25 years old are said to exist at a height of from 1100 to 1200 metres. Italian and Provence are the principal varieties ; Hungarian has given equally good results, being used in the northern part of Switzerland in particular. The Canadian variegated lucerne has also been successfully cultivated in many places, but trials of Cossack and Grimm have not fulfilled expectations.[39]

HUNGARY.

Lucerne is proved to have been cultivated in " Transdanubia " three decades (1587) before the confusion of the Thirty Years' War.[41] During the sanguinary conflicts of this war, which laid whole tracts of land in ruins and ashes, the cultivation of lucerne became extinct. Nearly one and a half centuries elapsed before it was reintroduced, at that time when increased interest was displayed in the promotion of forage crop production. In 1770 red clover was introduced into the country from the Steiermark and Upper Austria by Görög and Kerekes. In 1779 the Pastor Samuel Thessedik of Szarvas in the Comitat of Békés, who holds a place of honour amongst the pioneers of Hungarian agriculture, brought 2 lb. of lucerne seed from Vienna. His efforts to establish lucerne in Hungary were entirely successful ; his lucerne field soon attracted the attention of farmers, who came from all parts to Szarvas to obtain seed of the new forage plant.[42] From these small beginnings developed the Hungarian lucerne which is to-day one of the most valuable varieties in Europe. Johann Moisisovics, [43] a Protestant clergyman of the Comitat of Turocs, rendered great service in the distribution of lucerne by producing in 1804 the first book on the crop published in Hungary, a translation of a German work by Georg Friedrich Kromberg.

Lucerne played an important part in the forage crop production of Hungary before the World War, but has become more prominent since the Treaty of Trianon. Because of the loss of the districts where heavy rainfall prevailed, the cultivation of red clover declined in importance to one half of its previous area ; on the other hand, lucerne, the forage plant of arid districts, asserted itself and superseded red clover. The lucerne area in 1923 comprised approximately 419,900 acres, the red clover area on the other hand only about 296,400 acres.[44] In subsequent years the lucerne area became somewhat reduced, but it has recently increased again considerably.

From the purely geographical point of view the lucerne distribution in Hungary may be divided into four large districts,[45] on the right and left banks of the Rivers Tisa and Danube respectively. There are naturally certain ecological and botanical differences in these districts ; for example, the weed flora shows quite definite distinctions, but the main question is not influenced thereby. When climatic factors are considered, the great importance of lucerne for Hungary becomes clear. Hungary has a continental climate, which fluctuates between wide extremes and is on the whole inclined to drought. The summer is dry and hot for long periods,

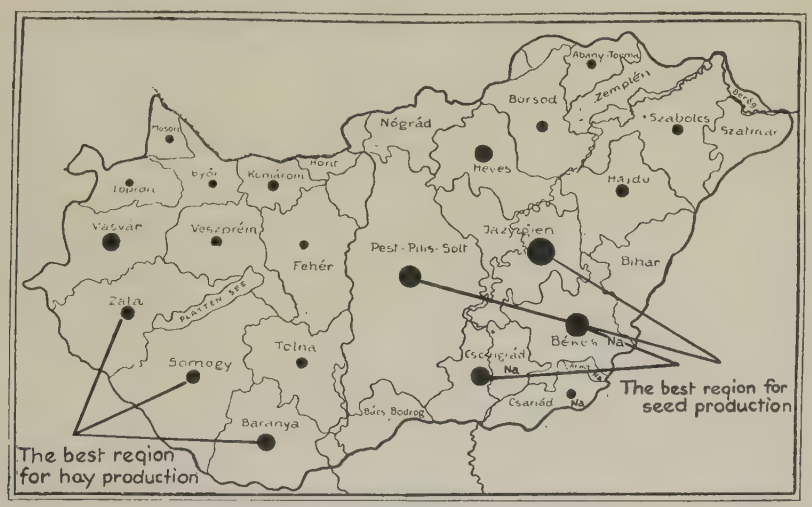


FIG. 5. LUCERNE DISTRIBUTION IN HUNGARY (according to A. von Degen).

the winter to a large extent without snow and extraordinarily cold, temperatures as low as -30°C. being not infrequent. A. v. Degen, the eminent authority on Hungarian lucerne, reports a temperature of -27° for Nyiregyhaza in the winter of 1929 and -28.2°C. for Kaposvar.[46] By decades of natural selection, Hungarian lucerne has been enabled to withstand temperatures below zero for months at a time, and has thus produced very vigorous and winterhardy types. Injury from fungous parasites is seldom incurred ; only in the seed production districts does *Uromyces striatus* Schroet. at times cause considerable damage.

The Hungarian lucerne consists in the main of *sativa* forms, the value of which is universally recognized. Of particular importance are its power of rapid regeneration (four to five cuts are the rule in Hungary), its great winterhardiness, and its tolerance of long periods of drought. Hungarian lucerne has attained a position of great importance far beyond the boundaries of its own country, especially for lands where the winter is cold and the summer is long and hot. It must be noted, certainly, that Hungary is not always in a position to export any appreciable quantity of seed ; rather is the import of seed necessary when there has been a bad seed crop. When seed is imported it is generally of Rumanian origin, or, on account of its low price, from Italy. Provence lucerne, which is actually more suitable for Hungarian conditions, has never been so popular as Italian lucerne on account of its higher price. Trials of Turkestan lucerne have had negative results in Hungary, as in all other European countries, even in the driest localities.[47, 48] It has been noted also that the roots of Turkestan lucerne are not so strongly developed as those of the European forms and are not so branched. In addition nodule formation, although normal, is yet much less vigorous than in the Hungarian lucerne.

One district stands out in the Hungarian lucerne area and is becoming of increasing importance. This is the Great or Lower Hungarian Plain (Pester Basin), the so-called Alföld, which is bordered on the north west, the north and east by the Carpathians, and on the west and south by the Danube. The Alföld lies only 70 to 120 metres above sea level ; its lowest point is

along the banks of the Tisa and its tributaries, and it is considerably broken up by moorland and swamps. Lucerne is propagated practically all over this district with the exception of the extremely salt soils and shifting sand soils. The mean annual temperature amounts to 10.5°C.; precipitation in the lowland is, according to Hédjas, 500 to 600 mm., with islands in which it falls to below 500 mm.; in Transdanubia it amounts for the most part to 700 mm., and exceeds this in the western part of the country. Some of the islands with heavier rainfall are to be attributed to mountain conditions, as at Pécs, in the Bakony forest, in the Matra and in the Bükk mountains.[49]

In the Alföld also is situated one of the most important breeding stations for Hungarian lucerne.[50] At the edge of the Great Hungarian Plain between the watershed of the Matra mountains and the Tisa lies Kompolt (the Kompolt station of the Seed Breeding and Seed Utilization Company on the Kompolt-Parade Estate). Here are found all the conditions necessary for breeding resistant types, including, for example, long periods of drought.[51]

Lucerne in the Alföld is grown principally in the deep, limy, medium clay or loam soils and in loess. The best strains are grown in slightly alkaline loam soils, where a deep water table is of special importance. On pure sand it does not thrive particularly well, and indeed gives satisfactory results on light land in Hungary only if the subsoil is binding and dry.

On comparing lucerne distribution and precipitation in Hungary, the influence of the plant's original home is clearly seen. The best hay production district lies mainly in the moist region, whilst the seed production area is found in the arid region. Here also are found the oldest Hungarian lucerne fields, from fifteen to twenty years old, which cannot be distinguished from the three or four-year old fields as far as density of stand is concerned. Certain parts of the Arad, Csanad and Békés Comitats should be mentioned here, and also the south eastern part of the Pest Comitat, which all have soils containing a small amount of sodium, with a tendency to dry up very considerably on the surface.[52] It is in just these soils that the most valuable seed is produced.[53]

Hungarian seed may very often be distinguished by the presence of typical small lumps of earth, as a large part of the seed ordinarily sold comes from the Alföld black soil district. The earth differs from that found in Russian seed by its greater adhesiveness and slightly shiny surface. These characters, according to A. v. Degen, are derived from the sodium content of the Hungarian black soil.[54] Hungarian seed which is exported is sealed by the Government Control Stations, and this seal serves as identification. Certainly much more lucerne seed is sealed than is actually produced in Hungary, the reason for this being that seeds grown in what were formerly Hungarian districts are cleaned in the Budapest seed-cleaning institutions and subsequently receive the Hungarian seal.

ITALY.

Lucerne came to Italy at a very early date, but it disappeared in the Middle Ages and was not reintroduced from Spain until the sixteenth century. Heracles Cuccho at that time brought lucerne from Spain to Naples, whence it was carried into Northern Italy. In 1544 V. Cordus gives an account of lucerne cultivation there. Later Heracles, a Bishop of Viterbo, had it cultivated in the vicinity of Rome.[55]

Jethro Tull in the year 1711 saw no lucerne south of the Alps, according to the description of his travels in Italy.[56] With the decline in the cultivation of lucerne its name, "herba medica," was also forgotten. It was re-named "erba spagna" or "spagnuola," names which are still used in many parts of northern Italy to the present day.[57] The usual name to-day is "erba medica."

Lucerne is at present distributed throughout Italy, with perceptibly greater density in the northern provinces. The farther south one goes, the less is the proportion of lucerne to the cultivated area, but even in the province of Calabria and in the islands of Sardinia and Sicily the crop is still grown in considerable quantities.

In the north lucerne is principally found in the valley of the river Po and in Emilia, and in addition in the central part of Tuscany, in Umbria and in Lazio.[57] In southern Italy lucerne has to be irrigated if it is to survive the long summer. It is grown in Campania, while in the

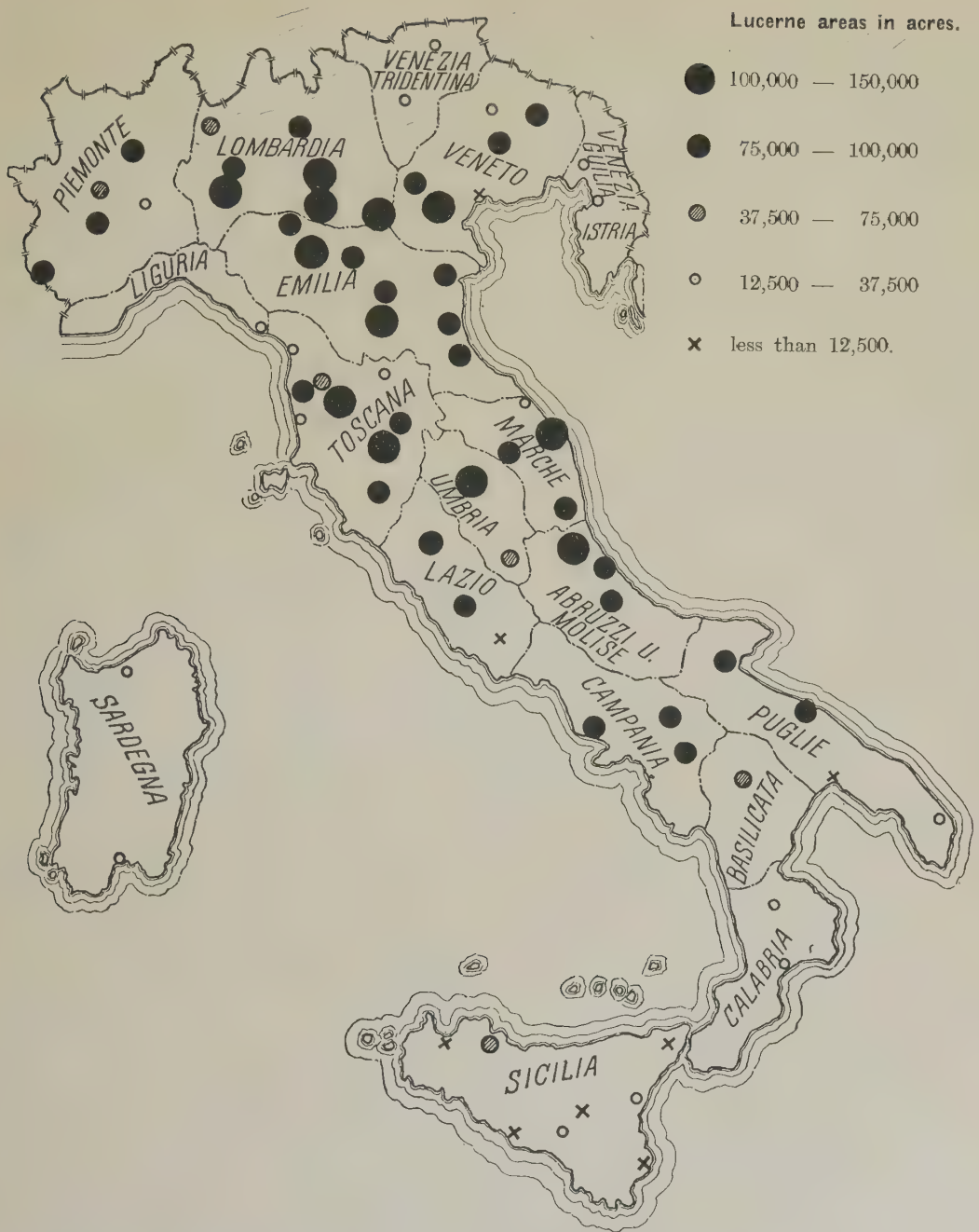


FIG. 6. LUCERNE DISTRIBUTION IN ITALY (according to Bavili).

Abruzzia, the valleys of Pescara and Sangro are particularly well known as lucerne districts. Other important lucerne districts are Pavia, Brescia, Cremona and Mantova (Lombardy) ; in the Emilia province Parma, Modena and Bologna ; in Venice lucerne cultivation is concentrated about Padova. In central Tuscany, Siena and Florence should be mentioned, and farther south Ancona, Perugia and Teramo. Emilia is the most important district for lucerne seed production in Italy ; in addition it is grown in Venice and Lombardy, whilst seed from Piedmont is rare.[38] The seed of Italian lucerne is smaller grained than the Provence seed. It is possible to distinguish between them with certainty, however, only by a study of the weed seed content. In this connection a brief summary is given which is in general agreement with the results of Oberstein.[58]

	Provence.	Italian.
Torilis nodosa	+	+
Helminthia echioides	+	+
Centaurea solstitialis	+	+
Cephalaria transsilvanica	—	+
Trifolium supinum	—	+
Hedysarum coronarium	—	+
Arthrolobium scorpioides	+	+
Lathyrus Aphaca	—	+
Andropogon halepensis	—	+
Salvia pratensis	—	+

As regards climatic factors, abundant precipitation is said to increase lucerne yields quite considerably. The quantity of rain which falls from April to June is considered to be decisive for the size of the crop.[59] This, however, is probably only partially correct, since Italy, on account of its deficiency in forests, has a naturally low rainfall and the summer is therefore for the most part very dry.

Lucerne management in Italy is of interest. Whilst in most countries lucerne is not included in the crop rotation, its inclusion is customary in Italy, especially in Emilia. Conditions here closely resemble those on the Norfolk sand in the Atlantic region of the United States, with the difference that in America the short duration of the plant is the decisive factor. In Emilia, lucerne is cropped in alternation with wheat and also with vegetables, which in this connection take the same place as root crops. The soils in Emilia are to a large extent deficient in potash, so that here, unlike most other districts in northern Italy, manuring with potash is essential.

Examples of lucerne in crop rotation in Italy (according to Busse).[61]

Piacenza.

1st year	maize, tomatoes, onions, beets.
2nd year	wheat.
3rd or 4th years	lucerne.
6th or 7th years	wheat.

Parma.

1st year	tomatoes or maize, potatoes, beets.
2nd year	wheat with clover sown in.
3rd year	clover.
4th year	wheat.
5th to 8th year	lucerne.
9th year	tomatoes.
10th year	wheat.

The importance attached to the cultivation of lucerne is shown by the attempts which have been made to introduce this forage plant into the Colonies, as for example at Genale in Italian Somaliland.[60]

FRANCE.

France takes a prominent place among the lucerne growing countries, the area under this crop being the largest in Europe. In the Departments of Hérault and the Pyréneés Orientales, lucerne cultivation reaches the extraordinary proportion of 25 per cent of the arable area. Much lucerne is grown also in the region stretching from the Belgian frontier to the plain near Paris.[62] It finds very favourable conditions in the vineyard climate of the valleys of the Meuse, the Moselle and the Rhine, immediately adjacent to the German lucerne area. In Luxemburg also lucerne plays an important part, its area covering more than 16,000 acres.[63]

The principal lucerne districts are Provence and Languedoc, including the valleys of the Rhône and the Durance. The Departments Drôme, Vaucluse, Bouches du Rhône, and Charente Inférieure are of special importance, followed by the Departments of Isère, Gard and Hérault. In the severe climate of the plateau and in the cold, wet north-western districts the cultivation of lucerne is of no importance. In the north-western coastal districts the profitable growing of lucerne is hindered by the tendency of lucerne fields to become overgrown with grass.[62] The lucerne district in the neighbourhood of Paris, in close proximity to the river Seine, with its preponderatingly chalky soil, borders on the Departments Calvados, Orne, Eure and Eure et Loire, a clover area with chiefly granite soil and high rainfall. It should be noted that the area in northern France is connected with an important sheep rearing industry for which lucerne forms the most important fodder.[63] Provence is considered to be the best lucerne district, the crop grown here being superior to all other French varieties in persistence and yield. The seed of the Provence variety is designated " lucerne du midi," whilst the variety from the Poitou district is

FIG. 7. LUCERNE DISTRIBUTION IN FRANCE (after Kuleshov).
Each point represents an area of 125 acres.

called " lucerne du pays." The seed of this last named variety is generally of a poor colour and is exported only when there has been a bad seed crop.[38] The genuine Provence seed is easily distinguished from the Languedoc seed since the grains are much coarser and the seed contains small yellow stones with conchoidal fractures. The Languedoc seed is smaller-grained and generally contains fragments of shell.[64, 65] The different varieties are all more or less similar, but their characters have been slightly influenced by the different climates of the districts whence they emanate. The Alpine varieties are said to be particularly valuable for their winterhardiness. In Languedoc lucerne is generally sown in pure cultures, whilst in Normany, for example, it is customary to sow under a cover crop. In the lucerne district in the neighbourhood of Paris both processes are employed. There is an interesting custom in the neighbourhood of Avignon which dates back to older times. Farmers here were in the habit of manuring their ground by ploughing in the lucerne stand as soon as the crop began to fail. The field was then sown again with cereals and lucerne. The ploughing is said not to destroy the old lucerne stand, so that the old roots become established again and combine with the newly-sown plants to give a good stand.[66] Hybrid lucernes are most frequently found on the banks of the Loire between Saumur and Nantes.[67]

The French farmer frequently uses his lucerne for three years only and grazes it in the fourth year. It is occasionally included in the crop rotation.[13] By using the crop for such a short time, full use is made of its beneficial effect upon subsequent crops, even although the lucerne roots in this short time cannot penetrate deep enough to utilize the nutrients of the subsoil. *M. sativa* in any case is not deep-rooted. Von Dungern[68] reports that during the war he saw wonderful lucerne in Artois, although the soil could be used only for a depth of 50 or 60 cm., the layer below this consisting of gravel or chalk. This lucerne was generally only of 3 or 4 years' duration. Hybrid lucerne on the other hand penetrates much further into the soil. The French farmer usually limes a ploughed-up lucerne field heavily. He does this even when (as in the neighbourhood of Cambrai, in Artois itself, and in Picardy) the upper soil lies immediately upon white chalk.[69]

Belgium and Holland.

In Belgium and Holland lucerne cultivation is of subsidiary importance because of the unfavourable climatic conditions in these countries. In Holland the greatest part of the lucerne area, which amounts to only 7,500 acres, is situated in Zeeland.[70]

Spain.

The lucerne grown in Spain comes from a coastal district with a temperate climate, distinguished by long summers and mild winters. In appearance the Spanish lucerne cannot be distinguished from southern French varieties, and it is not always possible to distinguish the two varieties even by means of the weed seed content. Certain adulterations are, however, typical of Spanish lucerne. In addition to small stones, as a rule milk-white quartz, one finds characteristic small lumps of earth of a yellowish, reddish or grey colour, which, when rubbed between the fingers, disintegrate into a fine, dust-like powder. These adulterations come from the loess soils characteristic of the great steppe areas of Spain. Fragments of loess soil are never found in seed from the south of France. Adulterations of a similar nature, but slightly different in colouring, occur in lucerne seed from Turkestan, which also emanates from steppe areas.[71]

Two quite distinct varieties of lucerne are found in the north and south of Spain respectively. The former is called Bilbao lucerne and the southern variety Murcia, after the districts in which their cultivation is centred. The Murcia variety is a very vigorous form, but is very susceptible to frost ; if introduced into Germany it succumbs to the first winter almost without exception. The Bilbao variety does not give the same bulk, but is much more winterhardy, being similar in this respect and in yield to strains from the south of France.[22] A further variety found in Spain is called the " broad-leaved Elche lucerne." It grows principally in the neighbourhood of the town of Elche and is distinguished by unusually large leaves. In Trabut's opinion it is descended from Algerian forms.[72, 73] The occurrence of wild lucerne in the neighbourhood of Villamayor is reported. Fraile[74] collected wild lucernes by the roadside at Villares de la

FIG. 8. LUCERNE DISTRIBUTION IN SPAIN.

Reina and mentions their high capacity for resisting drought. To distinguish them from the cultivated lucerne these forms are described as " mielga " (wild lucerne). The plants are not erect and are frequently found as weeds in fields, from which they are eradicated only with difficulty.[75]

The best lucerne is grown in the neighbourhood of Totana in the Province of Murcia, the most suitable district for seed production. It should be emphasized that in Spain also the best seed comes from a district with an especially arid climate (annual precipitation amounts to less than 400 mm.). The largest areas of lucerne are in the Provinces of Saragossa, Navarre, Lerida, Barcelona, Seville and Cadiz ; it is also found to a smaller extent in other parts of the country.

ENGLAND.

In England lucerne has been grown for a considerable period without much possibility of its attaining any economic importance, since climatic conditions make its development so uncertain. At the end of the nineteenth century the lucerne area of Great Britain was 35,570 acres, increasing in the course of years to 48,160 acres. Lucerne growing is concentrated mainly in Essex, Kent, East and West Suffolk and Hertfordshire, the greater part of the lucerne area (70 per cent) lying in the south-eastern and central counties of England.[76, 76a] In the western counties it has been grown only in Gloucestershire, Wiltshire, Shropshire and Glamorganshire in Wales[77], without becoming established to any extent ; in Scotland also its cultivation is of little importance. The northern limit of the area of possible cultivation falls on the east coast, coinciding approximately with the 53rd latitude, whereas in Germany, on the Baltic coasts, it lies between the 54th and 55th latitudes.[62] In England, with its heavy rainfall, it will never be possible for lucerne growing to be practised extensively. The wet summers which are general stand in the way of its permanent cultivation, although during dry years it comes into favour again with English farmers.[78] It is worthy of note that more than three-quarters of the total lucerne area lie in a region where the annual rainfall does not exceed 750 mm. In the comparatively dry years of 1904 to 1908 a steady increase of the lucerne area took place, but the wet years of 1909 and 1910 produced a reaction. After the dry years of 1911 and 1924, an increased growing of lucerne was noted, and this was true in part of the year 1929.[79] There is scarcely another area in which the influence of the arid home of lucerne is so clearly and convincingly seen, reflected in the annual returns, as in the British Isles. Lucerne seed can be produced in England only in really hot summers, and that from the second cut. The first cut is as a rule too luxuriant and tends therefore to become rotten during the flowering period, whilst seed of the

FIG. 9. LUCERNE DISTRIBUTION IN ENGLAND (after Thornton).

third cut does not ripen. Provence is the type generally grown ; in variety trials conducted by Messrs. Sutton and Sons, Reading, Provence took the first place.[80] Grimm lucerne has given as good results as Provence ; in the first years the Provence lucerne is decidedly superior, but with increasing age Grimm assumes the first place. The sowing of lucerne under a cover crop has proved to be extremely detrimental to its development.

SCANDINAVIA.

Lucerne was first cultivated in Scandinavia to an appreciable extent about the period 1770 to 1780. During the 19th century it was grown only sporadically, and not until the end of the century did it attain any importance in a few districts in the south.[81] Lucerne growing is centralized in east Scania,[83] with its northern limits not far from Upsala.[82]

SWEDEN.

Sweden possesses its own variety, the so-called Ultuna lucerne, a hybrid form with yellow and blue flowers, and having a high degree of winterhardiness.[83] Trials have shown that Ultuna lucerne is superior in this respect to Hungarian and even to Grimm, at least in the Scandinavian climate. (Ultuna is situated approximately 60 degrees north). In the very severe winter of 1910-11 Hungarian lucerne, for example, disappeared entirely, whilst the Ultuna variety was only slightly damaged. In yield also Ultuna lucerne takes a high place.[84] In general, however, varieties are grown which are obtained from Germany and originate almost exclusively from Hungary.[85]

NORWAY.

In Norway lucerne is found as far north as the 59th latitude, but is of no economic importance whatever, as red clover cultivation is much more profitable. Damage caused by frost forms a further hindrance to its cultivation. The efforts of a seed merchant, O. Malthe, to establish an indigenous lucerne bred by himself and named " Malthei " were unsuccessful.[86]

DENMARK.

In Denmark the growing of lucerne increased steadily up to 5 years ago, but during the last few years it has given way more and more to the increasing cultivation of red clover and of white clover-grass permanent pastures.[87] Only on the loess soil of the islands and in the eastern part of Jutland has lucerne cultivation become established.[63]

POLAND.

Lucerne cultivation is scattered over many parts of the country, with the exception of the northern region ; about 30 per cent falls within the province of Poznań alone. There is great variability in the yield obtained in different parts of the country ; in the eastern districts with their short growth period yield is very low, in the western districts (Poznań and Pommerellen), and even in the lucerne areas of Warsaw and Lodz, twice as much is harvested. Seed production of *Medicago sativa*, which is the species almost exclusively grown here, is confined within narrow limits. Hybrid lucernes are very rare.[88]

BALTIC STATES.

The economic importance of lucerne is very small, as it is seldom found in this region. The first trials were made about 100 years ago.[89]

FINLAND.

The crop is very little grown, a lucerne field being seldom seen even in continental localities.[90]

GREECE.

This was the first European country in which lucerne settled on its migrations. At that time it must have rapidly attained a position of great importance, as is seen from the fact that it is frequently mentioned in Greek literature (Aristophanes, Aristotle, and others). In modern Greece, however, it is seldom grown, according to Stebler and Volkart. The decline of arable farming and therewith of lucerne cultivation was closely bound up with the fall of the Greek State.

BULGARIA.

Lucerne cultivation was introduced into Bulgaria about four decades ago, and now covers about 0.2 per cent of the total cultivated area. Only the *sativa* form is grown. The necessary seed is to-day produced almost exclusively in Bulgaria itself and amounts annually to an average of more than 1400 bushels. The relatively high seed yield may be explained by the favourable climatic conditions. In the vine-growing climate of Bulgaria lucerne thrives very well, so that the seeds mature at the correct time, although there is naturally considerable variation in yield. The seed harvests of Bulgaria equal those of Italy or the United States, and are considerably superior to that of, for instance, Bavaria. Seed production in Bulgaria is still very primitive. In most cases the seed is threshed out in the threshing yard and removed from the pods by primitive methods. It is comprehensible that the quality of the seed suffers from this treatment.[91]

RUMANIA.

Lucerne has become widely distributed in Rumania, where even before the war (1907) legal measures had been taken to place the cultivation of forage crops, and therewith of lucerne also, upon a broader basis. By means of the free provision of lucerne seed, by coercive measures

and by the awarding of cash prizes a great increase in the lucerne area has been produced,[92] and the area has actually doubled in the years 1921-28.

	acres.
1921	135,423
1922	198,413
1923	244,856
1924	206,690
1925	259,251
1926	251,552
1927	286,275
1928	271,901
1929	281,749

In the period 1910-14 more than 500,000 kg. of lucerne seed were imported into Rumania.[93] The Rumanian lucerne area has been greatly enriched by the Hungarian territory which has been acquired, this Hungarian land alone forming almost 50 per cent of the total cultivated area.[94] After Transylvania, the old Kingdom of Rumania possesses the greatest lucerne area, whilst those of Bessarabia and Bukowina are much smaller. The mountain districts of Rumania and the region of the Upper Moldau are considered to be particularly suitable for the growing of lucerne. It is preferably grown on soil containing clay and rich in phosphorus. The extension of the lucerne area does not coincide exactly with the suitability of the districts in question as regards climate and soil type, for economic reasons. The most suitable areas for growing lucerne are the chernozem and brown soil regions of the Plain of the Danube and the western plains. It grows excellently on the alluvial soils of the flooded district of the Danube valley, provided the water table is not too high. On light land no satisfactory results have been obtained. The development of lucerne cultivation in the Provinces of Siebenbürgen and Banat, which to-day belong to Rumania, may be traced back to the year 1779. After 1800 lucerne cultivation spread from these Provinces to all parts of the old Kingdom. The lucerne forms at present grown in Rumania are probably of French origin ; through a long process of acclimatization that mixture of forms has arisen which is known to-day by the name of Rumanian lucerne. Rumanian lucerne is credited with high yield and disease resistance in addition to great longevity, winter-hardiness, and excellent germinability. Of foreign strains only Provence seed has played any important part ; Turkestan lucerne is grown in Bessarabia to a limited extent. In the Plain of the Danube lucerne generally gives three cuts, of which the last is small. In very dry years lucerne in the Steppe district scarcely gives one cut, at the most two. Only the southern districts of Rumania are of importance for seed production.

TURKEY.

The lucerne of Turkey is known far beyond the borders of the country itself by reason of the Kaisarie strain, which comes from the vilayet of the same name. In this district, situated in the interior of the country, lucerne occupies a large area. According to Christiansen-Weniger lucerne varieties coming from the district of Konya or from land lying still further west are sold under the name of Kaisarie lucerne. The Kaisarie lucerne is winterhardy and adapted to the extreme variations of temperature of the Anatolian spring. Its requirements with regard to soil are small ; it is, for instance, grown on light land at the Experimental Station of Ankara. Much greater importance is attached to abundance of water than to soil type, for without irrigation it would be impossible to grow it in arid districts. " Little intensive lucerne cultivation is practised as yet. The spring is preferred for sowing, at all events in the actual continental climate region. The field is laid fallow before lucerne is sown and receives as far as possible an abundant dressing of farmyard manure. In order to facilitate irrigation lucerne is sown down in well-levelled beds which are surrounded by low parapets. It is customary to sow it both in pure cultures and also under cover crops. The cover crops chosen are, in accordance with the district, wheat, barley or millet. When pure cultures are sown the seed is mixed with sand to facilitate scattering. Irrigation is carried out by flooding the individual beds. The number of cuts varies according to climate from one to seven. The cut is generally taken very late or after the plant has fully flowered, as the farmer attaches more importance to quantity than quality.

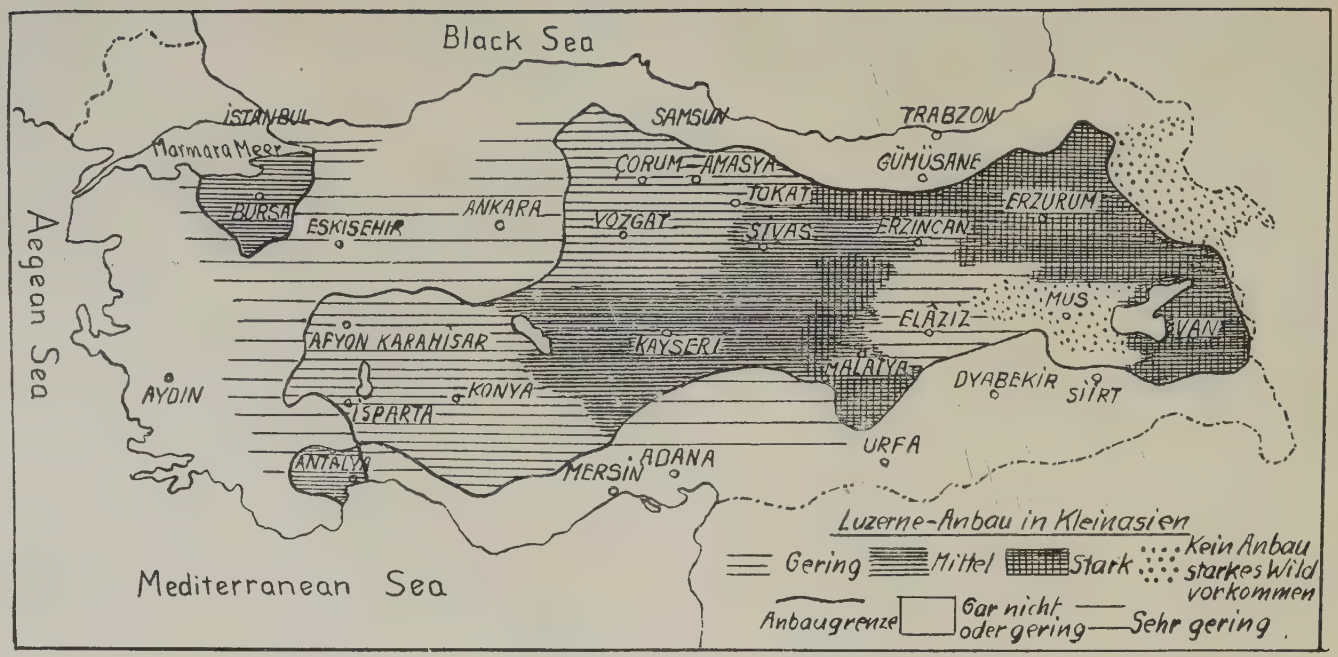


FIG. 10. LUCERNE DISTRIBUTION IN ASIA MINOR (after Christiansen-Weniger).

Classification.

"Gering" .. little grown.
"Mittel" .. a medium amount.
"Stark" .. much grown.
"Kein Anbau, starkes Wildvorkommen" .. common wild, but not cultivated.
"Anbaugrenze" .. cultivation limits.
"Gar nicht oder gering" .. almost or entirely absent.
"Sehr gering" .. very little.

Special cultural methods are on the whole still unknown. In the neighbourhood of Kaisarie permanent lucerne cultivation is said to be conducted in many fields. When the lucerne dies out, the fields are ploughed up and are sown down afresh. Anatolian lucerne is very vigorous, perhaps somewhat coarse-stemmed, and tends, unless it is cut early, to become woody. It contains very broad-leaved types. In this climate development in spring is very early and subsequent growth is vigorous. It is very resistant to frost. There is also no material reaction to sudden repetitions of cold weather, such as often occurs during the Anatolian spring."

Unirrigated areas of Kaisarie lucerne are found in the mountain climate of the east, where the crop grows well. In these districts severe snowy winters and short hot summers with low rainfall are the rule. The best lucerne hay is produced in the valleys of the vilayets Malatya, Mus and Siirt, in the east of Turkey. How favourable the conditions for lucerne cultivation are may be seen from the fact that in Eastern Anatolia wild forms of *Medicago sativa*, *M. falcata* and of their hybrids are found in great numbers. In the coastal region of the Black Sea with its heavy air moisture, and in the neighbourhood of the Aegean Sea also, lucerne is entirely lacking. It is observed by Christiansen-Weniger that in Eastern Pontus the proportion of Leguminosae is altogether very small. The lucerne area is limited to inner Anatolia and increases from central Anatolia towards the eastern highland. It falls into two groups, the one having a continental climate with dry hot summers, and the other a cold climate in the east with snowy winters. Lucerne seed production is still conducted by very primitive methods, so that the seed is very often heavily adulterated. Recently the Turkish Government has endeavoured to improve this state of affairs by the erection of a modern lucerne cleaning plant.[96]

EUROPEAN U.S.S.R.

Lucerne was introduced into Russia from two directions; it first came from what were then the European centres of lucerne cultivation, Spain and the south of France, and later a lucerne hybrid was introduced into Russia from eastern Asia under the name of "Musci" lucerne.[97] The following notice concerning the introduction of the new lucerne probably refers to this "Musci" lucerne: "Vassiljev, the Master of the University of Kasan, who was attached to the Russian Mission in Peking for a period from 1840, sent in 1847 to his friend Karatajev, an estate owner at Nishninovgorod, a number of seeds of a forage plant (a lucerne species, called 'Mu-su' by the Chinese) which had been brought by Chinese soldiers from Bogdychan (between Turkestan and Tibet) to China and was grown in the neighbourhood of Peking by order of the Chinese Emperor. This plant is said to produce such nutritious hay that it is considered by the Chinese to be as valuable as grain fodder. Mr. Karatajev, who is growing the crop and has exhibited its hay at the Nishninovgorod Experiment Station, confirms this and further reports that it grows very well in the Nishninovgorod climate and gives two cuts, one in June and the other in September. As the plants are said to become easily entangled in a luxuriant stand, which makes mowing difficult, it is advisable to sow down some grass species together with this lucerne. In China millet is employed for the purpose."[98]

The lucerne area in European Russia is of slight importance only (see table), as in the Black Soil region in which it is grown red clover is more widely cultivated.

Lucerne areas in U.S.S.R. (1928) in acres. According to Belov.[8]

Central Asia	508,963
Northern Caucasus	69,580
Ukraine	37,050

On the north the area extends as far as the Government of Saratov. In Samara, in the neighbourhood of the Ural, one of the coldest Governments of Russia, the most winterhardy variety known is cultivated.[99] There are other local varieties in the Caucasus; for instance, in the district between Duschet and Passanaura a narrow-leaved variety is found growing upon rock detritus washed down from the mountains. The Erivan lucerne is of most importance here, known locally under the Tartar name of "Yondjin." In Yelisavetpol it is maintained that the Erivan lucerne will persist for ten years, whilst the Turkestan lucerne is of only six years' duration in this district. Erivan has a climate which is semi-arid to arid, with cold winters, generally without snow. Summers are hot and dry, for which reason lucerne is grown under irrigation at

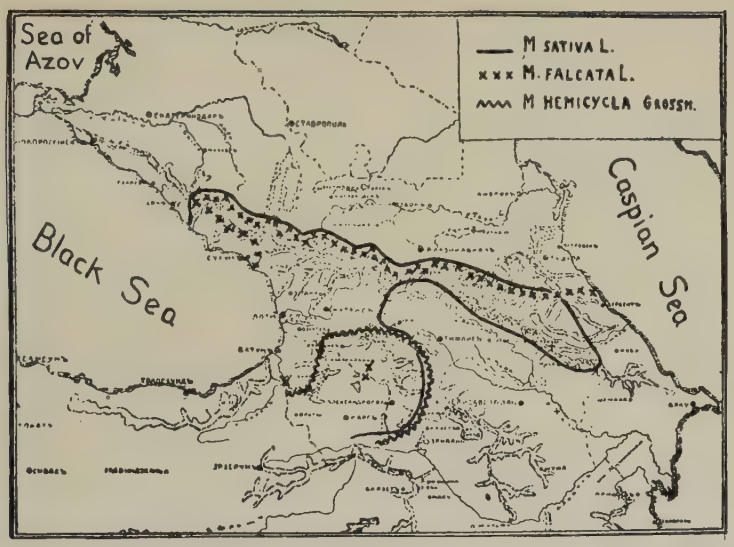


FIG. 11. THE DISTRIBUTION OF *M. sativa* L., *M. falcata* L., AND *M. hemicycla* GROSSH. IN THE CAUCASUS (after Troitzky).

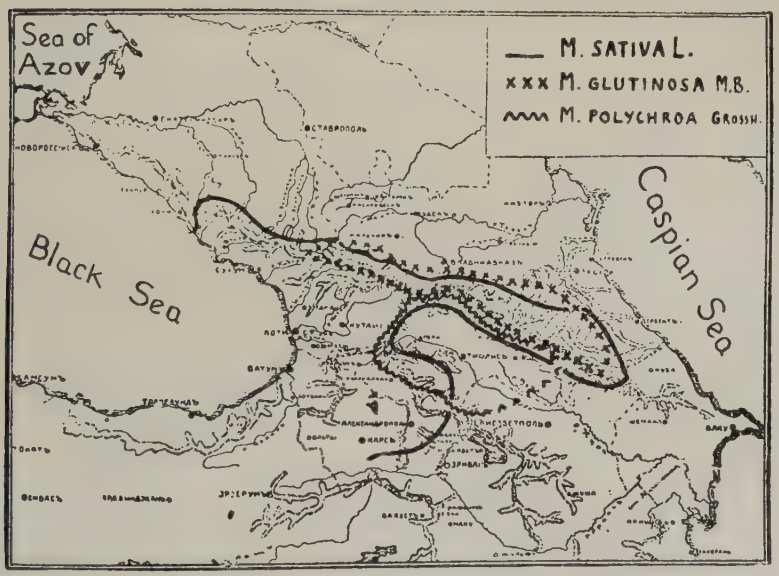


FIG. 12. THE DISTRIBUTION OF *M. sativa* L., *M. glutinosa* M.B., AND *M. polychroa* GROSSH. IN THE CAUCASUS (after Troitzky).

FIG. 13. AREA IN WHICH *Medicago sativa* GROWS WILD.

this season. Heavy rain is general in spring and autumn.[100] The Kuban district, where lucerne has been grown for 45 years, is considered the best area in southern Russia. In the southern part of the district, where the soil is deep, lucerne is used for 10 or 12 years, in the northern part only for 4 or 5 years.[101] In Transcaucasia the lucerne area, in itself not very large, is of great importance, as it is distinguished by a great variety of forms of the genus *Medicago*. Amongst other wild species is *Medicago hemicycla* Grossh., of the same morphological type as the German hybrid lucerne (*M. media*). The *M. hemicycla* area represents a small portion of the *sativa* area, in the only district of the interior of central Caucasia where *M. falcata* L. is to be found wild. Its distribution and morphological characters make it appear probable, according to Troitzky,[102] that this species is a hybrid of *M. sativa* and *M. falcata*. Also in the central part of the main mountain range *M. glutinosa* M.B. occurs, with an area of distribution adjacent in the south to that of *M. polychroa* Grossh. These two species are morphologically intermediate between *M. glutinosa* and *M. sativa*, for which reason Troitzky concludes that they also are hybrids. Troitzky's observations (for which, it is true, no proof has yet been produced) make it appear certain that the cultivated lucerne, *M. sativa*, also contains as a result of natural hybridization characters from species not yet taken into consideration ; this conclusion is all the more probable since *M. sativa* to-day can hardly be regarded as a homogeneous species. If, for instance, two forms, the Provence and the Anatolian lucernes, both designated *M. sativa*, are compared, they are seen to vary so considerably in their morphological and physiological characters that their classification in the same species cannot be justified. Trabut's view[103], which denies all existence of *M. sativa*, is too extreme. It may well be that the lucerne found in North Africa arises from a hybridization of *M. falcata* and *M. gaetula* Urb., but the existence of *M. sativa* cannot be doubted. The only certainty is that the present definition of the species *M. sativa* does not correspond to the actual state of affairs. It would be well if this question could be taken up in the right quarters and if these controversial points could be cleared.

In Transcaspia, as in the rest of central Asia, Turkestan lucerne is almost exclusively cultivated. Lucerne in these districts is almost the only forage plant, and the lack of meadows still further emphasizes its importance. The stands are of about 8 years' duration and may be cut 5 or 6 times a year. The crop is sown here in a peculiar way, preferably in a field which has been artificially flooded. By this means the worthless parts of the seed, which float on the surface of the water, are removed. When the water is then drained off, the good seeds, which have sunk to the bottom by reason of their weight, germinate uniformly. As this method of sowing involves a considerable amount of labour, lucerne areas are found only on the " Mülk " land and never on the " Sanaschik."[104] (By " Mülk " is understood fields near dwelling houses which are included in the irrigation plan and are regularly cultivated, the rest of the arable land being known as " Sanaschik.")

SOVIET CENTRAL ASIA.

In the south of Lake Aral, immediately adjacent to the boundaries of western Turkestan, lies the former Vassal State of Khiva, which is watered by the Amu Darya. In the oases of this State, which is outside the loess zone, lucerne is grown and is even said to be eaten as a vegetable by the natives. Agriculture in this country still stands at a very low level of development and is based on a primitive method of irrigation, the water being drawn in buckets attached to wheels turned by animals. The whole district is covered by a network of canals which carry the water necessary for irrigation. The individual pieces of land, which are very small (as a rule less than $2\frac{1}{2}$ acres of arable land), are very intensively farmed and everywhere heavily manured with compost. The latter consists principally of deposits from the irrigation canals and is used to the extent of 40 or even 70 tons per acre.[105]

In Turkestan lucerne was a stable factor of the agricultural crops as early as the days of Alexander the Great, coming from Media across the south-eastern coastal lands of the Caspian Sea. Busse[2] assumes that lucerne had first to pass through a lengthy period of acclimatization in the Turanian oases before it reached its present form. The type which we know to-day as Turkestan lucerne has developed under ecological conditions such as will scarcely be found anywhere else. The crop is grown on every farm, even on the smallest, a fact which points emphatically to its great economic importance. Without lucerne, cattle raising would be practically impossible in Turkestan, as the steppes, which in spring give an abundance of fodder, dry up completely at the beginning of summer, and in places halophytes and camel grass become established.

Turkestan has a marked continental climate with sharp contrasts between summer and winter.[106] In the summer months high temperatures prevail and the air has a relatively high moisture content, whereas in the winter the thermometer falls far below zero without the lucerne plants being protected from the effects of frost by a sufficiently deep covering of snow.[107] The great majority of the soils in the Turanian area are of Aeolian formation. The brown and grey earths which have come from loess, and the loess soils themselves have a high content of particles which can be washed away, they are rarely fine-grained and are, moreover, distinguished by their high content of water soluble salts and very alkaline reaction.

An interesting feature of lucerne cultivation in Turkestan is that it is included in crop rotations. In the Turanian area it occupies quite a different relative position in the various provinces. Whilst in most districts in Turkestan lucerne can be grown only under irrigation, in the south it is grown in dry fields also,[108] where are produced larger hay crops than from natural steppe pastures. As a rule lucerne is not sown down under a cover crop unless climatic conditions are very favourable. In order to improve the water relations of the soil, it is frequently customary to cover the surface with manure or chaff. The dry farming of lucerne is still only tentative, and there does not exist any lucerne type as yet which can be used exclusively for dry farming. All attempts to produce seed from these dry fields have given little success. The dry fields generally give one cut only, in the first part of May, and regenerate very slowly afterwards. The correct date of cutting must be adhered to exactly, as otherwise the leaves drop at once and thus the most valuable part of the lucerne is lost.

It is not correct to speak of " Turkestan lucerne " pure and simple, as is so often done. Turkestan lucerne may be divided into types differing considerably in their physiological constitution. The type of climate in the different districts is shown by the following comparison of three well-known lucerne areas :—

	Summer.	Winter.
Aulieata (in the Syr-Darya district)	temperate	severe
Tschimkent (East Turkestan)	temperate	not cold
Khiva (West Turkestan)	hot	mild

The coldest northern area of Turkestan is found in the immediate vicinity of Verni, which produces a type known as " Verni " or " Tschilik " lucerne.[109, 110] The spontaneous distribution of the *sativa* form covers the whole of Turkestan, according to researches conducted by Russian botanists. Prianischnikov[111] assumes that the Turkestan lucerne is closely related to the Chinese lucerne or " Mu-su " (*Medicago sativa chinensis*), which was brought to Russia from Tibet in 1847.

According to Belov[112] the following forms may be distinguished to-day :—

1. Mountain type.
2. Khivian type.
3. The central Turkestan and Semiryechensk type.
4. The Khorosan and Turkmen type.

The mountain form of Turkestan lucerne, which is found not only in the mountain districts, but also in districts on the northern boundary of the *Medicago sativa* area, has a spreading habit and almost prostrate, fine, and much-branched stems. The number of stems is small, the leaves are small, the inflorescences loosely attached. It is a late small-seeded type, which only regenerates slowly. The main root is very fine. The high degree of winterhardiness possessed by this form is connected with the deep position of the vegetation point in the soil. The Khivian type, which is very susceptible to *Pseudopeziza*, is found in the lower course of the Amu-Darya, the principal seed production area. This type also has a spreading habit, and has numerous coarse and much branched stems, with a high leaf proportion. The leaf itself is coarse, round, and of medium size. The flowers are dark violet, the pods of medium size, coloured brown, seldom yellow, the seeds of medium size. The salient fact is that the snail-shaped spirals in this form are particularly dense. In spring the growth period begins earlier and more vigorously than in the form previously mentioned, to which must be attributed its better performance. The Central Turkestan type is semi-erect, branched to a medium extent, and has numerous stalks and large elliptical leaves of medium coarseness. The leaf itself is longer than in the Khivian type, the seeds are smaller, smoother and of a greenish colour. In contrast to the Semiryechensk type hard-coated seeds are rare. The pods exhibit shades varying from pale yellow to dark brown. The period of vegetation is longer than in the previously mentioned forms, beginning earlier in spring and extending later into August. After cutting it forms a rosette of bouquet-form which is not typical of lucerne ; this rosette is very loose and much larger than in the Khivian type. The central Turkestan form gives the best crops of all the Asiatic lucernes ; in winter-hardiness it is inferior to the Khivian form, but superior to the Khorosan type.

The eastern part of the Seven River District is the principal area of the Semiryechensk type, which is intermediate between the Khivian and the central Turkestan forms and is characterized by a large hard seed content.

The Persian province of Khorosan, Afghan Turkestan, the Herat province and in part also the Kuschka district and Tachta-Basar form the principal area of the Khorosan type, which has an erect habit and coarse, short stems with few branches. The internodes of this form are comparatively long. The number of stems and leaves is small ; the leaves themselves are large, narrow and wedge-shaped, the stipules are pointed. Flowers, for the most part light in colour, are situated in small loose inflorescences. The seeds are of a greenish colour, small and flat, the pods mostly very yellowish with three or four spirals. The Khorosan form has the longest period of vegetation of all central Asiatic lucernes, but is inferior to the central Turkestan form in consequence of the smaller number of stems and the lower proportion of leaf. No formation of rosettes is seen after mowing. It is not capable of withstanding low temperatures, and is very liable to become mildewed, the third cut being nearly always completely destroyed. The Turkmen form is grown on the cultivated areas of the Kopet-Dagh Mts. and in the valley of the River Sumbar ; it is more spreading and taller than the Khorosan type. The two forms are very similar, but in the Turkmen form the leaves are more numerous and larger, and growth begins later in the spring.

Turkestan lucerne has not attained great importance in any other district beyond the Turkmenian area, although it appears on the market in great quantities (its annual export is estimated at 300,000 pud) and on account of its low price is used in all parts of the world.[113]

Although in 1908 Stebler and Volkart reported that Turkestan lucerne was successful in the continental central States of North America, this is no longer true at the present day.[38] It is a specialized type which has arisen from centuries of adaptation to climate and soil, and, when introduced into quite different climates or soil types, it is certain to react by diminished performance. In a natural condition the seed of Turkestan lucerne may be easily identified : it has neither the attractive ochre-yellow colour which is typical of Provence lucerne, nor the normal shining appearance.[114] The surface of the seed is of a rough, sandy texture and is nearly always covered with a fine layer of dust ; the colour is greyish-yellow to greyish-brown.[23] Although it is comparatively easy to identify Turkestan lucerne, this becomes impossible if the seeds are polished or made to appear shiny by means of grease. In such cases it is possible to identify it only by means of the weed seed adulteration.[115] In leaf form it may be distinguished by its smaller and rounder leaves, for which reason it was formerly described as *M. sativa* var. *rotundifolia*.[116] In the United States it has been found that Turkestan lucerne is distinguished from less cold-resistant varieties by the greater number of its lateral roots and fibrous roots.[117] Hiltner[118] stated that Turkestan lucerne in his trials only very occasionally exhibited nodule formation, and to this he attributes its failure. In trials conducted later at Magyarovar in Hungary, nodule formation in the Turkestan lucerne was, however, quite normal in every case, although it was much less than in the Hungarian lucerne grown for comparison.

PALESTINE.

According to S. Zemach[119], of the Agricultural Experiment Station at Tel-aviv, lucerne, which has been known in the neighbourhood of Damascus for generations and is called " Fussa " there[117], was first brought to Palestine forty or fifty years ago by members of the American Colony, to be grown in small patches on their farms. Its cultivation did not spread to any extent, however, until the year 1925 and later. To-day small, good lucerne fields occur in the Valley of the Jordan, in the eastern part of the Plain of Esdraelon and also in the coastal plains, and the area increases year by year. The best lucerne areas are situated in the limy, permeable loam soils of the Jordan Valley, and also in the heavy loam soils of the Valley of Esdraelon, provided there is sufficient lime content. Good results have also been obtained on light land.

Lucerne is grown in Palestine exclusively under irrigation. There are no indigenous varieties ; hairy Peruvian and Provence lucerne are grown on the heavy lime soils, whereas on light land Chilean lucerne is preferred. The crop may be cut seven or eight times per annum, yielding from 30 to 40 tons per acre. With unskilful irrigation root rot is a common occurrence.[120] Another *Medicago* species (*M. coronata* (L.) Gaertn.) is very remarkable on account of its high degree of drought resistance. It is distributed in all parts, but its occurrence on the mountain slopes is particularly interesting as the soil here is only a few centimetres above the rocks. The seed setting of this variety is very high, the seeds themselves are small.[121]

ARABIA.

Lucerne, called by the natives " Bersim hagasi," i.e., clover from the Hagas-Hedjas,[122] has been cultivated for many centuries, being known in the pre-Christian era. The structure of the country makes it impossible for a consecutive area to exist. As a rule lucerne is watered here every ten days during the summer months, in cooler summers only twice a month. An interesting feature of its cultivation is that the fields are dressed with stable manure after every cut. Nine or ten cuts are usually obtained per year, the average duration of the crop being estimated at seven years. Characteristics of the Arabian lucerne (also called Djet or Jet) are its marked hairiness, delicate hollow stems, great power of regeneration and the typical form of the leaves, which are comparatively broad in proportion to their length.[123] Another distinguishing feature of the Arabian lucerne is its erect growth habit, only the crown spreading slightly at times. The flowers correspond in general to the normal type except for the colouring, which is dark violet. In its physiological constitution the Arabian lucerne bears a certain resemblance to the Peruvian lucerne, although differing morphologically in the form of its leaves. The Arabian type is not winterhardy and is less drought-resistant than the usual forms of the *sativa* type, but it can withstand high temperatures without injury if there is adequate soil moisture.

It has indeed a preference for high temperatures, which is probably explained by its adaptation to the climatic conditions of the regions in which it has been grown for centuries. Because of its capacity for growing in cooler weather, Arabian lucerne has a longer period of growth than other varieties.[124] In this it resembles the Peruvian type, which is, however, capable of growing in still lower temperatures. The duration of Arabian lucerne in other districts is very short when compared to that in its native land, for which reason it is generally grown in orchards. In the third year the loss begins to become considerable, and amounts to 50 per cent and more in the subsequent year. As compared with the ordinary forms it certainly gives more cuts per year, without the hay yield being any larger. The hay itself is of good quality. Seed production in Arabian lucerne is unreliable.

PERSIA.

In the pre-Christian era the great importance of lucerne was already recognised in Persia, especially as forage for horses. To-day also it is a very popular forage plant. The horticultural cultivation of lucerne is of great importance in Persia. " In many districts nearly every house is surrounded by a garden of several square metres in size, surrounded by a mud wall of about 2 metres high. The gardens are situated inside the village and within the town wall. In other places in Isfahan, Hamadan, and Aserbeidjan enormous gardens are situated outside the towns and villages for many miles around. At the edges of the gardens on both sides of the irrigation ditches fruit and mulberry trees, poplars, planes and willows are planted. Inside the gardens vines are found first and foremost, and also legumes, melons, cucumbers and lucerne. A Persian garden is thus a combination of what we call vineyard and kitchen garden."[125]

Lucerne is grown both for green fodder and for hay, especially as meadowland is comparatively rare in Persia. As a rule seed is produced only for local purposes, although seed from the south of Persia is said to appear upon the market occasionally under the title of " Turkestan lucerne."[113] Indigenous varieties are grown almost exclusively. Lucerne is cultivated on a great variety of soils, with few exceptions under irrigation. There are great differences in the climate of the lucerne area in Persia : in the highlands, for example, as much as 15 to 20° of frost may occur ; in the southern Persian area, on the other hand, the temperature rarely falls below zero during the winter months. A striking feature is the almost complete absence of weeds, probably due to the fact that the fields are fallowed ; in the dry climate this discourages the growth of weeds even when no soil cultivation is carried out.

CHINA.

Lucerne, in common with other important crop plants, came into China by way of eastern Turkestan.[126, 127] Of the beginning of general lucerne cultivation in China there are no historical accounts, and even in recent days the plant is rarely mentioned in literature.[128] According to a French missionary[129] the Chinese distinguished seventy years ago between the cultivated blue-flowered form (*Medicago sativa*) and the wild form with yellow flowers (*Medicago falcata*), a distinction which is no longer valid, as *Medicago falcata* now has to be counted amongst the crop plants in China. In northern China, south of the Transbaikal region, *Medicago falcata* is grown to a large extent.[113] Chinese lucerne is distinguished by great winterhardiness and is considered therefore more suitable for continental climates than the ordinary lucerne forms.[130] One of the best known lucerne areas is the Province of Shensi in north-western China, where it is also customary to use the plant as a vegetable. The lucerne grown here is said to grow on many types of soil.[131] The Province of Shensi, situated south of the Great Wall, has a very high summer temperature, while the winter, which lasts here for three months, is very cold.[132] In the neighbouring Province of Kansu also lucerne is widely grown. A wild species (*M. ruthenica* (L.) Gaertn.), reported from the neighbourhood of Titaochow, is found principally on the loess highlands at over 2,000 to 3,000 metres above sea level in a semi-arid climate. It is small, low, and of creeping habit.

Further types of ordinary lucerne and of *M. ruthenica* are reported from other districts of China and Mongolia, where they grow under a variety of soil and climatic conditions.[133, 136] In Chinese Turksetan (Eastern Turkestan) lucerne is of great economic importance, especially

in the region of Kashgar, which largely consists of desert, crops being grown only in the valleys. The commercial roads between western Asia and China traverse this region. Types of lucerne which occur here include one with hollow stems, a " fibrous lucerne," and a " black lucerne " with dark green leaves. Seed production of these forms is attended by difficulty. In the oasis of Sandju (1,800 metres above sea level) seed of the " fibrous lucerne " may be obtained in small quantities, whilst the " black lucerne " does not ripen at all and seed has to be obtained from abroad.[136] *Medicago falcata* is found on wheat fields 2,000 metres above sea level as a common weed.[137] Wagner[138] mentions a form, *Medicago astragalus denticulata*, which is said to be grown to a large extent. This two-year lucerne is sown down in rice fields when they are in flower, and is said to thrive very well after overwintering. The early growth of this lucerne is eaten fresh as a vegetable and highly esteemed by the natives. The woody parts of the plants are later made into compost with other materials and employed as manure.

In reviewing the lucerne forms found in China, it can be seen that *M. sativa* and *M. falcata* are found in all parts of the country, but nowhere are forms mentioned which can be the result of hybridization between these two species. It is not yet clear whether no attention has yet been paid to the hybrid lucernes, or whether hybridization has not occurred between *M. sativa* and *M. falcata*.

INDIA.

That it is possible by means of suitable cultural methods to grow lucerne successfully in tropical lowlands, even under unfavourable climatic conditions, is shown by the area in British India. Formerly lucerne was grown only in higher localities which were irrigated by means of canals. The disadvantage of this method lay in the low yields obtained and in the large quantity of water required for irrigation. Lucerne very frequently died back during the summer months as the soil became encrusted and its temperature rose. To-day lucerne is grown in flat plots separated by irrigation ditches some 30 cm. wide, which serve during the rainy season to drain the plots and aerate the soil. When the plots are sown, seed is also sown in the irrigation ditches, so that the field at first gives the impression of a closed stand. In the rainy season the lucerne at the bottom of the ditches dies back. The advantages of the new method of sowing are many ; in addition to increased yield, the danger of dying back (during the hot season) is diminished. Soil structure is not damaged physically and a considerable amount of water is saved.[139] According to Howard, who has rendered great service in the promotion of lucerne growing in British India, lucerne may be cut as many as eleven times a year under this method of cultivation.[140] The greatest advantage of the new method, however, consists in the increased longevity of the lucerne. Whilst lucerne formerly could be grown for only one year, the new method permits it to be grown for two and even three years in the same field. After being under lucerne for several years, the ground is thoroughly ploughed up at the end of the rainy season and a heavy topdressing of Chinese compost is applied.

The first attempts to grow lucerne were made with seed emanating from Kandahar, in Afghanistan, where large areas are covered with lucerne. The possibility was even envisaged some years ago of exporting lucerne seed in appreciable quantities to Russia. The Kandahar lucerne is certainly capable of growing under high temperatures ; in cooler weather, however, it ceases growth, for which reason it has been replaced by another kind from Kalianpur in the neighbourhood of Cawnpore, North Western Provinces. The Bu-Kusk lucerne, which is distinguished by small size and fine branches,[141] was introduced into India from Iskardo in Afghanistan. In the Punjab lucerne is especially highly esteemed by horse-breeders. Poona lucerne comes from the eastern slopes of the Western Ghats ; it is not very winterhardy. The seeds are harvested in March and the ley is generally of three years' duration. The seed is comparatively expensive, but is generally three times as successful as that produced in the vicinity of Surat, nearer the coast. Lucerne is here cultivated in sugar cane fields for seed production only.

Ladak lucerne originates from the same kind of country as the Bu-Kusk lucerne, i.e., lower Tibet, Balti or Baltistan. Ladak is situated in the high mountain region of northern India at the foot of the Karakorum, and is watered by the Indus. This lucerne is very vigorous in growth, resistant to heat and cold, and distinguished by high seed-setting. A further characteristic is

its high yield in the first cut ; indeed it takes a foremost place for average annual yield among all varieties. The excellency of its hay is also noted, the stems being very fine and leafy. In India it is grown chiefly as fodder for horses and sheep. Seed production in most districts in India is very difficult. Howard attributes the low seed-setting to the fact that, whilst the pollen grains are normally developed, they do not germinate in the prevalent high temperature. Experiments showed that when the pollen grains were artificially cooled they soon germinated. Lucerne seed is produced in the Punjab and to a slight extent in Pusa also, but there is an increasing tendency to transfer seed growing to the cool regions of north-west India and the hill country.

TROPICAL AFRICA.

The successful cultivation of lucerne has been reported also from the tropical zone of Africa, and in particular from the former German Colony, German East Africa, where Provence lucerne was grown in Usambara[147]. The sowing down of a lucerne field here certainly requires rather excessive trouble and care.[148] The cost of upkeep, however, which is limited in the main to irrigation, is but slight and from five to seven cuts may be obtained. According to Engler[149] lucerne also thrives well in the mountain countries of tropical Africa.

LUCERNE AND MALARIA.

Even if the cultivation of lucerne has attained and will attain no great proportions in these last named areas, yet on the other hand, according to recent medical research, it seems to be of great importance in the sterilization of the mosquitoes which carry malaria. The general interest which may be attached to the results of this research induces me to mention briefly its main points. Willcox's theory that the relative freedom from malaria in Egypt was due to the extensive growing of lucerne in that country, in that the lucerne sap consumed by mosquitoes brings about the destruction of the malaria germs which they carry, led a Russian doctor, Theo Krysto,[151, 152] to adopt the same theory, which was supported by his own experience in the Caucasus and on the Transcaucasian Railway, as well as in the south of the United States of America. It is well known that the malaria mosquitoes live not only on the blood of men and animals, but also on plant saps. Before Krysto, the Frenchman d'Herelle had explained the relative freedom from malaria in large parts of the Argentine Republic by the extensive cultivation of lucerne and similar plants.[150]

ALGERIA.

There is extensive cultivation of lucerne in the irrigated parts of the coastal region. On the high tableland only a little lucerne is grown, but in the oases it has attained great importance as a forage plant. The neighbourhood of Sétif, which is situated relatively high and is often subject to frost, is well known as a lucerne-growing area.[153] The plant is also found growing spontaneously on the high plains near Bordj bou Arreridj on calcareous and at times very dry soils.[154] Trabut mentions an endemic narrow-leaved herbaceous form with white flowers, which he calls *Medicago sativa gaetula* Urban.[155] The soil in which the lucerne grows has a high salt content, especially in the oases, and is generally of a loamy nature. The deleterious effects of the saline soil are not, however, apparent, as a high percentage of the salt is washed out of the soil crust by the irrigation water. If the lucerne is planted in the shade of date palms, as is often done, the date palms also prevent an efflorescence of the salts on the surface. In addition, the soils of the oases are very rich in gypsum, which also helps to neutralize the injurious effects of the salt. The lucerne grown to-day in the coastal area originates almost exclusively from Provence. In the arid lucerne area there grows in addition to the Turkestan lucerne (which has been very successful, particularly on the very saline soils) a native variety, the growing of which becomes more concentrated in the eastern part of the high mountain region in the vicinity of Sétif. The lucerne from the neighbourhood of Tougourt in the Algerian Sahara is particularly well known. In this district a small patch is to be seen in nearly every garden, generally in the shadow of date palms. Tougourt lucerne is of high quality, juicy, thin-stemmed and almost completely glabrous. The leaves are large and thin. It is a strictly specialized type, the good qualities of which become entirely lost in, for example, the moist coastal region,[156] where the stems become dwarfed and very hairy. A local form is the so-called " luzerne de temacine."[157]

TUNIS AND TRIPOLI.

Brief mention should be given to its cultivation in Tunis, for example, in Qabes and in the Kebilli oasis, and in Tripoli, where it takes about eight months to grow. In Tripoli a lucerne called " khobezy " is grown in addition to the usual form ; it gives large yields and has a higher proportion of leaf than the lucerne previously mentioned, and its seeds are much cheaper.[158] Lucerne is watered every four days, giving up to eight cuts yearly.[159]

EGYPT.

A local variety from the neighbourhood of Hegazi is well known, and the crop is also grown near Khartoum.[160] The seed employed is mostly from Lower Asia, as indigenous seed, which cannot be produced in adequate quantities, is very expensive. European seed is unsuitable for the climatic conditions of Egypt, as they are adversely affected by the desert winds.[161]

SOUTH AFRICA.

Lucerne was introduced from France into what was then the Cape Colony about the middle of the last century, and soon became of great importance in this country, particularly on the large ostrich farms, then almost in their prime.[162] Although the economic importance of the ostrich farms has meanwhile undergone a fundamental change, the cultivation of lucerne is still on the up-grade, and it is regarded to-day as one of the most valuable forage plants of the Union of South Africa.

The cultivation area covers practically the whole Union, but the crop is particularly valuable for the arid and semi-arid districts, where it is grown under irrigation. In the semi-arid Karroo, lucerne has been so widely adopted that fields of varying size are found on every farm, in accordance with the amount of water available for irrigation. The two foremost districts are

FIG. 14. LUCERNE DISTRIBUTION IN THE UNION OF SOUTH AFRICA (after Bosman).

Graaff Reinet and Oudtshoorn.[163] Oudtshoorn, which is famous for its lucerne throughout South Africa, is one of the most important hay producing districts, and also the largest lucerne seed producing district of the Union.[164]

The forage yield is very low, which may be attributed to the heavy demands made upon lucerne for pasturage. As regards seed production, yield varies greatly in accordance with the climatic factors; for example, in 1919-1920, 754 tons were exported, but in the subsequent period 128.5 tons. Cape lucerne seed is sent to the United States, Australia, New Zealand and England and is also occasionally found upon the European market. Its value outside its own growth area is relatively small, as is indicated by the fact that Cape lucerne is said to be fraudulently sold as Provence lucerne in Europe, and as Hunter River lucerne in Australia.

Climatic conditions within the lucerne area are not uniform. In the semi-arid area the crop is exposed to great extremes of temperature, whilst in other districts it grows under milder climatic conditions. Lucerne from these last named districts died back in the United States more than did the Argentine lucerne.[165] Cape lucerne is generally sown down in autumn, the rainy season, so that early growth is ensured, and in addition weed development just at this time is a negligible factor.

Besides the actual Cape lucerne, which has emerged from imported Provence lucerne into a special type and is to-day morphologically and physiologically different from Provence, other types are also grown, as, for example, on the Orange River. In this district small lucerne fields form the principal source of fodder, apart from the native grasses. The lucerne that is grown here must be classified in the same group as Peruvian lucerne from a physiological point of view, which is quite comprehensible, as climatic conditions here resemble those of the Peruvian lucerne area in the United States (Yuma, Arizona, etc.). Another variety which is very popular on extensively cultivated farms is said to show a certain similarity to Grimm lucerne, and is often considered to be actually Grimm lucerne.[166] Of far greater importance than the forms already named is the Chinese lucerne. It was introduced into South Africa about ten years ago, and was soon held in great esteem. This Chinese lucerne, belonging to the *Medicago sativa* group, was introduced by Fairchild, an American, into arable farming in the west.[167] Fairchild collected lucerne seeds in the mountains of the Tibetan frontier at a height of about 3,700 metres; these he subsequently took to the United States and reproduced.[178] The advantage of the Chinese lucerne over the other varieties grown in South Africa is longer duration of vegetation. The Chinese lucerne is very winterhardy; by growing earlier in spring and later in autumn it gives one and a half more cuts than the other varieties. It is valued more particularly in the humid coastal area, where it is more widely grown to-day than the Hunter River lucerne formerly so popular. The Chinese lucerne is further credited with the advantage of growing on slopes just as well as in valleys, and also in high localities, where it is said to reach a height of as much as 1½ metres. It is also said to thrive on saline soils.

PERU.

Lucerne came direct to Peru from Spain. It is considered here to be by far the best forage plant and has become absolutely indispensable, as there is a great lack of natural pastures excepting in the highest regions, which are almost entirely uninhabited. Localities of between 1,000 and 3,000 metres above sea level are the most suitable; the upper limit is 3,600 metres. Very moist and very warm districts are unsuitable for lucerne. It is grown on different soil types. The seed used is mostly home produced. As a rule the crop is used fresh, although it is carried in the form of hay into a few districts which are poor in natural fodder.[170] The Peruvian lucerne has grown for many decades in an equatorial region where annual variations of temperature are comparatively small. The temperatures in summer are not as a rule very high nor are the winters very cold. Peruvian lucerne, of which there is one smooth and one hairy variety, is easily distinguished by the structure of its leaves, which are three to five times as long as they are wide. Physiologically it is distinguished by poor winterhardiness. In every district where the temperature falls below a certain point during the winter months Peruvian lucerne dies before any other variety. It may seem paradoxical that slight frosts do not even temporarily hinder the growth of Peruvian lucerne, which is also true of Arabian lucerne. In districts with mild

winters the growth of winterhardy varieties ceases almost completely, whilst those varieties which are particularly susceptible to cold grow continuously, so that the first cut of Peruvian and Arabian lucerne can be taken as early as the end of February.[123] This may be explained by the fact that these forms continue to grow in temperatures in which winterhardy varieties still remain dormant. Peruvian lucerne has in suitable localities numerous advantages, such as a far more vigorous growth and more rapid tillering after cutting. Under favourable climatic circumstances it can grow the whole winter through, and thus can produce one or two more hay cuts per year. Its disadvantages are its hairiness, at least in the case of one variety, and its tendency to lignification ; these disadvantages may be obviated to a certain extent by thicker sowings. Lack of winterhardiness will always confine Peruvian lucerne to certain areas, and its tendency to become woody makes it unsuitable for large districts (arid regions) which can produce good crops only with thin sowing.[171]

Under the climatic conditions which are favourable for the growth of Peruvian lucerne, the flowers are easily pollinated and give an abundance of seed. Cool weather encourages seed-setting far more than decidedly high temperatures. The well known " San Pedrana " variety comes from the coastal region in the vicinity of San Pedro near Pascamaya, being grown preferably on loose sandy soil with a moist subsoil. It has an average duration of four years only ; it is distinguished by high yields and can be cut the whole year round about every six weeks, as compared with only six cuts of the ordinary variety (" native lucerne ").[172] Seed from the neighbourhood of Supe is particularly highly esteemed in the coast lands of Peru, while another variety, very similar to the smooth Peruvian lucerne, is said to be grown in very high localities near Kandarava. Peruvian lucerne has become particularly important in the south of the United States, where it is found at the present time in Arizona and California under the names of " Hairy Peruvian " and " Smooth Peruvian." It is grown to a smaller extent in New Mexico, Texas and the coastal regions of the south-eastern States.

CHILE.

In Chile lucerne takes the foremost place amongst forage crops. In the central Provinces it is called " alfalfa " ; in the north " alfa." It grows remarkably well in saline localities, but falls an easy victim to night frosts in central and southern Chile.[173] According to Opazo[174] lucerne is grown in Chile from Tacua in the north to the river Bio-Bio in the south, that is to say approximately from 18 to 37° latitude south ; further south it occurs only in a few particularly favourable spots. The best areas are in the neighbourhood of Santiago, Aconcagua, Coquimbo and Atacama. Lucerne flourishes best in the arid districts of Chile ; an exception to this rule is Huasco on the northern coast. In the Andes of northern Chile lucerne is the only cultivated plant which is grown in the higher localities.[175] In the valley of the river Copiapó one finds numerous smaller lucerne areas. Lucerne is an important article of commerce in this country, as it is sent dried in bales to the copper mines situated in the mountain wastes. Within its own area lucerne is grown on soils which differ very considerably. It is also grown on sandy soils, but here no good results have been obtained with the *sativa* form. Hybrid lucerne, which gives much better yields under these circumstances, has been grown only in small quantities up to the present. Of the native varieties, which are known under the collective name of Chilean alfalfa, Huasco and San José de Maipo should be mentioned.[176] Huasco is situated in northern Chile, and seed from this type, which has probably originated from the hybridization of a native variety with Peruvian lucerne, is particularly highly valued for its vigorous growth and excellent hay.[177] Both Huasco lucerne and that from San José de Maipo have long become acclimatized, are hardy and generally grow all through the winter in the central zone.

The best seed grows in the Cordillera, on the slopes of which are to be found wild forms growing in moist virgin soil. It is interesting to note that, in spite of irrigation, annual precipitation is often directly correlated to yield in the individual years. In the rainy year of 1926 (740 mm.) native lucernes, that is to say those which were well acclimatized, exhibited a far higher degree of vigour and hardiness than in the subsequent year, which had a low rainfall (420 mm.). Foreign varieties exhibited converse behaviour. Of the introduced varieties, Provence and Peruvian lucerne have proved best for Chilean conditions. Provence is very winter-

hardy and gives very good yield in summer, but it shows little growth in winter. Both subspecies of the Peruvian lucerne are grown. " Peruvian coastal lucerne," which is of very vigorous growth and very tall, is little branched, tends to become woody and is very hairy ; " Peruvian mountain lucerne," which grows vigorously in winter, is distinguished by great leafiness (the leaves are hairy) and closely resembles Chilean alfalfa.

The following analysis, for which I am indebted to a letter from B. Wunder of Santiago, is worthy of note. " The analysis of the dried plant material of different varieties made in 1925 is very interesting. The Chilean, Canadian and Italian varieties and Grimm are distinguished by high proportion of leaf, whilst the Provence, Indian, Peruvian, Black Hill, Kansas and Hardigan have more stem. Cellulose content is considerably higher in the Peruvian, Italian and Canadian varieties than in the others, and Chilean and Ladak lucerne are particularly low in crude fibre."

The longevity of the Chilean lucerne is very considerable. Fields which are twelve years old and more and which yet give from six to eight cuts per year are no rarity. But it is not only for green fodder and for hay that lucerne is grown in Chile ; it is also of great importance as a pasture plant.[178]

ARGENTINA.

The most important lucerne area in the world is situated in Argentina, to which country the plant was introduced from the west across the Andes. The presence of wide areas of soil very suitable for the cultivation of this crop has caused the lucerne area to attain such proportions that it even tends to oust very productive natural grassland. Of the cultivated area in 1930 lucerne occupied 37 per cent, wheat 29, maize 14, flax 8, oats 4, and other crops 8 per cent respectively.

The remarkable increase in the area under lucerne in the course of fifty years is indicated by the following table.

	Lucerne area in acres.
1872	261,820
1888	763,230
1895	1,761,110
1913	16,524,300
1917	17,969,250
1921	20,999,940
1925	24,700,000

The estimated figures for 1929 (14,424,800 acres) indicate a considerable reduction.

The country has a great variety of climates. It stretches from the territories of Salta, Jujuy, and Formosa in the north, partly situated in the tropical zone, as far south as Tierra del Fuego, where as a result of proximity to the Antarctic it is much colder than in European countries of the same latitudes. The most important lucerne area is comprised by the Provinces of Buenos Aires, Cordoba, La Pampa and the neighbouring regions. Even in the northern part of the country, which extends into the tropical zone, lucerne is successfully grown here and there. Only in Patagonia and in the territory of Los Angeles, situated in the high mountain districts of the Cordillera, is lucerne no longer grown,[180] although Westover[177] reports the finding of an Argentine lucerne form at a height of some 3,000 metres on the Andes railway.

Widely varying climatic and soil conditions are, therefore, found within the Argentine Republic. The country offers an excellent example of the great ecological range of variation possessed by lucerne. It appears worthy of mention that in Argentine lucerne has settled in large areas consisting entirely of shifting sand. Under Argentine conditions a process of selection has taken place which has produced a peculiar lucerne type. The Argentine lucerne is no forage plant in the usual sense of the word ; it serves not only for the production of green fodder, hay and seed, but has also shown its suitability for pasture purposes without forfeiting its vitality on account of grazing. When it is compared with the crop grown in Central Europe it would appear as if an absolute conversion had taken place.[181]

The lucerne area in the Argentine Republic may be divided into two main groups, as follows.[182]

I. *Irrigated zone.*

1. National Territory of Chubut.
2. National Territory of Rio Negro.
3. The Province of Mendoza and the National Territory of Neuquen.
4. The Provinces of San Juan, La Rioja, Catamarca, Santiago del Estero, Tucumán, Salta and Jujuy.

The first three districts are those in which a superfluity of seed is produced, and from them originates by far the greater part of the Argentine lucerne which is found in foreign markets. In the last-named region only the Province of San Juan produces seed for sale, and this is mostly used in the Province of Santa Fé.

II. *Non-irrigated zone.*

1. The south of the Province of Buenos Aires and the south of the central Pampas.
2. The west of the Province of Buenos Aires, the north of the central Pampas and the south of the Province of Cordoba.

Argentine lucerne seed, which is superior to all foreign varieties in respect of germinability, is particularly popular. The seed production district is divided into three parts. The first part includes the irrigated crops of the Provinces of Mendoza, San Juan, La Rioja, some parts of San Luis, the north of Cordoba, Salta, Jujuy and Catamarca. The seed produced here has a high percentage of hard-coated seeds, often amounting to as much as 50 per cent. The seed produced in another district is characterized by a very small, but well developed, grain. This district includes in the south of Cordoba a part of San Luis, the north of the pampas, and the west and north-west of the Provinces of Buenos Aires and Mendoza, as well as the district of San Rafael. The percentage of hard-coated seeds here occasionally amounts to as much as 25 per cent. The seed is distinguished by a high degree of germinability.[177] The plants are of very vigorous growth, and are resistant to drought. The last seed production district, the seed from which is very highly esteemed, is formed by the south of the Provinces of Buenos Aires and the Provinces of Rio Negro and Chubut. In the Province of Rio Negro lucerne is generally cut four times a year, the second cut being taken for seed.[183]

The best seed is produced in definitely arid climates, in light soil with a permeable subsoil. The seed production districts of the arid zones never import foreign seed, so that the good characteristics of the seed they export are always maintained uniformly.

Two of the varieties grown should be particularly mentioned. Tucuman lucerne is of the same type as the hairy Peruvian, but considerably more vigorous and more persistent. " Alfalfa saludina " is a very hardy lucerne, resistant to trampling in the pasture and with rapid powers of recovery after cutting. A disadvantage of this variety is loss of leaves when it is ripe, for which reason it has to be cut when flowering begins. In addition it has a tendency to become woody. On an average it gives some seven or eight cuts. It is called " saludina" because it is less susceptible to injury from alkali and saltpetre than the ordinary lucerne.[184]

URUGUAY.

Lucerne was grown in Uruguay for the first time in 1776 by a priest, José Manuel Perez Castellano, near Montevideo, from seed obtained from Argentina. Uruguay, with its slightly undulating ground, unfavourable soils, and its poor soil water relations, does not offer favourable conditions for the growing of lucerne. The best district, where the crop is used almost exclusively for green fodder and hay, lies in the vicinity of the capital, Montevideo. In the Department of Montevideo, small in itself, about 1,000 acres are devoted to lucerne, and in the neighbouring department of Canelones about 8,650 acres ; the total area is approximately 14,500 acres. A considerable quantity is also grown in the Departments of Paysandu, Salto and Soriano. Foreign varieties from Argentina, France, Spain and Italy are grown exclusively.[185]

Beneath the upper soil layer, generally known as pampas loam and containing a considerable admixture of humus and in some places sand, is a subsoil of crystalline formation (granite

and crystalline slate). In the northern part of the country, where lucerne cultivation is of less importance, the subsoil described is surmounted by a younger sedimentary formation (sandstone, slate, marl, etc.). The chief lucerne areas are found on pampas loam soils of a sandy nature.

In spite of these difficulties there are many farms which grow lucerne successfully, owing principally to the peculiar use made of lucerne: in the vicinity of the city of Montevideo, in particular, it is retailed in quite small bundles.[186] The district where it is produced (Rincon del Cerro) is situated on the border of the Departments of Montevideo and Canelones. The method of farming employed here is described by Boerger[181] as follows: "For the growing of lucerne those deep rich soils in the neighbourhood of the capital, Montevideo, and particularly in the Department of Canelones, are sought and are prepared by the most careful tillage and manuring. Stable manure plays an important part in this preparation. Farmers often bring manure from the corrals of the great slaughter-houses and from the central collecting ground for cattle near Montevideo, and it is applied in doses of between 16 and 24 tons per acre. But in addition to this (especially recently, in consequence of modern manuring propaganda and improved transport facilities) it has become more and more customary to use the local phosphatic manures, available in the form of bone ash and bone guano from the same slaughter-houses. Altogether it is a form of lucerne cultivation very different from that which is conducted over extensive areas in Argentina with ease and without any manuring."

PARAGUAY.

The districts in Paraguay where lucerne can be grown are very limited. Generally it is only on the very loamy soils that it is worth cultivating; the seed is imported exclusively from Argentina. The soils of Paraguay are to a great extent deficient in lime and tend to become heavily overgrown with weeds. On good soil a satisfactory stand may be obtained in the first year, but it begins to deteriorate the next year, and as a rule it has practically disappeared in the third year. Only in the virgin soil of forest clearings can good crops be produced for several years, but the labour involved is so great that lucerne cannot attain any economic importance here.

BRAZIL.

In Brazil the lucerne area was originally small, situated in the south and immediately adjacent to the Argentine area.[187]

Now the crop has become more important, especially in the sub-tropical zone. In contrast to the suitable districts, where the temperature varies from 11 to 35°C during the growth period, there are found the less suitable districts of the granite region, where the temperature for the same period fluctuates from 5 to 37°C. The number of cuts which can be obtained is in consequence very variable. The amount of yield obtainable is governed by rainfall and facilities for irrigation. The average rainfall in the good districts varies from 1,400 to 1,550 mm., whereas in the granite region it varies from 750 to 1,750 mm. In the lucerne districts proper the distribution of rainfall is very favourable, whereas in the granite region it is concentrated within a comparatively short period. The amount of rain, in itself considerable, might appear surprising, but the soil absorbs approximately only one-fifth of this quantity. The soils vary from loamy types poor in potash and phosphorus, to those of the granite region where the land is sandy, poor in lime, with pH of 5.5.

The growing of lucerne here is therefore a difficult matter and possible only after very careful preparation of the ground. Murcia lucerne is the principal type grown, after which Grimm and Provence lucerne also are highly esteemed. On the dry lands forms of *Medicago polia* are grown. The slight extension of the lucerne area in the subtropical parts of South and Central Brazil when contrasted with its distribution in similar parts of Argentina and Chile may be explained by the question of cost. It requires a greater outlay to sow down new fields here, as for the most part these districts are still covered with forest. Sowing is generally done towards the end of the rainy season, when there is least danger of the heavier soils becoming encrusted. In the arid parts of the country irrigation is of great importance. It is carried out either by running the water in furrows or by flooding, and is continued as a rule from April to September. If the rainy season sets in late, irrigation is carried on into October.[187a]

ECUADOR.

The lucerne ordinarily grown in the highlands of Ecuador is generally found in very light, loose and sandy soil. A well known variety is the "Guaranda" lucerne, which derives its name from the capital of the Province of Bolova [123]; its cultivation is more concentrated in the neighbourhood of this town, which is situated at a height of 2,100 metres. Guaranda lucerne resembles Peruvian lucerne. My information on the growing of lucerne on the higher plateaux of the Andes is based on data given by Luis Sodizo. The estate of Velasco in the neighbourhood of the town of Pamasqui is situated at a height of 2,800 metres and has an average temperature of 15 — 16°C. with slight variations between day and night. The soil is sandy and adequately provided with organic matter. The water supply, although not over-abundant in comparison with the extent of the area cultivated, is adequate for the requirements of vegetation. A well cared for field should persist under good conditions for about thirty years. The ordinary lucerne of the Ecuador highlands is sold in Ambata; it is grown for the greater part in the vicinity of the town itself on very light soil. Characteristic of this vicinity is its low precipitation.[188]

GUATEMALA.

In Guatemala there grows near Antigua a form of lucerne which was probably brought into the country as long ago as the period of the Spanish colonization. It has always proved superior to Grimm lucerne and all the other varieties which have been grown here for purposes of comparison. Lucerne is grown in Antigua without irrigation and flowers even in the driest time of the year, although no rain falls from October until May. The average annual precipitation amounts to 750 — 1,000 mm. The water table in parts of the Valley of Antigua lies 2 metres deep. The fact that eight or ten cuts can be obtained annually indicates the vigorous growth of this lucerne in spite of the continuous drought.[189]

MEXICO.

From a purely historical point of view, Mexico is particularly interesting, as it is one of the first countries in the American Continent, if not the very first, where lucerne settled in the course of its migration. The plant was introduced into the country by the Spanish Conquerors about 1519, and penetrated later into the southern and northern halves of the Continent. When the lucerne areas of modern America are considered, however, the position of Mexico is comparatively insignificant.

The Mexican lucerne area may be divided into five zones, of which only the northern zones are of any importance for lucerne cultivation.[188] The principal area is in the Central zone, where almost half the lucerne production is to be found. This district takes the first place also for the quality of its lucerne, as Atlixco in the State of Puebla is one of the best seed producing districts in Mexico, and the State of Hidalgo produces the best forage lucerne.

In the next zone, the North Pacific, the State of Lower California is the most important. In the northern zone lucerne areas are concentrated in the States of Durango, Chihuahua, Coahuila. In the two remaining zones lucerne is of no great importance, the areas of both zones together containing only 2 per cent of the total lucerne cultivation. The State of Oaxaca in the Southern Pacific zone is the only one of any significance; indeed it is practically the only State in this zone in which lucerne is grown (99 per cent). From Oaxaca, where the greatest part of the lucerne seed is produced, comes one of the most valuable varieties of lucerne grown in Mexico. The Gulf zone is still less important than the Southern Pacific zone; the insignificant lucerne areas found here are divided between Orizaba and Tenango del Rio Blanco in the State of Vera Cruz. With an area of approximately 117,000 acres, Mexico produces from 1,700,000 to 1,800,000 tons lucerne.[190]

The yields in the various zones mentioned above depend to a varying extent on proximity to the influence of Atlantic and Pacific ocean currents.

As regards the distribution of lucerne within the individual regions, it is generally found only in the vicinity of the larger towns, where there are farms with livestock which send fresh milk to the towns and, of more importance, have enough water for irrigation purposes. Very little lucerne is grown without artificial irrigation, except in the State of Hidalgo.

The best seed comes from Atlixco in the State of Puebla. This type grows very rapidly, is very tall, has broad leaves and therefore gives good bulk. It has the advantage of producing good yields even in the winter with sufficient irrigation. Seed from Oaxaca is also good, but not so vigorous ; it gives good yields only in the rainy season and during the warmer part of the year, whilst in winter even with good irrigation it grows slowly and remains short. It generally produces a denser stand than the Atlixco lucerne, as its tillering is better. Whereas the Atlixco form if it is manured lasts for seven or eight years, Oaxaca lucerne generally lasts for only five years. Seed-setting is better in the Oaxaca lucerne than in the other variety, for which reason it is considerably more expensive. Lucerne is frequently sold as "Atlixco seed" which comes from Oaxaca and from foreign countries by way of Atlixco.

Foreign strains grown include seed from Arabia, Germany, Peru, Spain, Turkestan, and the United States, the Arabian and Peruvian varieties being particularly popular because their stems are very tender and therefore readily eaten by cattle.

Lucerne is mostly sown down on volcanic sandy soils, where it thrives best, especially as the heavy clay soils are unsuitable here for lucerne growing. A requisite of success is that the subsoil should be permeable, as otherwise the roots easily rot. On impermeable soil it is possible to grow lucerne only after drainage, but drainage is a process which is practically unknown. Only one drained farm is said to exist, the estate of Amducan in the State of Puebla, on sandy soil with a loam subsoil.[191]

" On the high plateau of Mexico, lucerne is sown down in rows 50 — 60 cm. apart. The rows are previously marked, drawn, and lightly opened with a hoe, and the lucerne seed is then strewn in the furrows in a mixture of one-fourth seed and three-fourths fine sand. For this purpose an old cow horn is used, at the tip of which there is a hole, which may be regulated by the forefinger as required and through which the seed is poured. The seed is subsequently covered with a light layer of compost. Sowing is best done at the beginning or in the middle of the rainy season. In order to avoid the complicated marking and drawing of rows, it is often customary to sow down lucerne in already existing maize stands. This is done in the following manner. It is well known that maize, like potatoes, is well heaped over with earth ; on one side of these earth heaps a seed furrow is drawn along with a hoe about three-quarters the height of the heap, and the lucerne is sown down in the furrows in the manner already described. The raised position of the seed protects it against too great moisture or the possible stagnation of rain water, and the already well developed maize plants protect the young lucerne plants against too intensive sunshine." [192]

The great value that is attached to lucerne in Mexico may be estimated from the fact that a good lucerne field near a large town costs from 1,000 to 4,000 pesos. Fresh cut lucerne is sold by weight at high prices, and, next to maize tops, is the best and the only green forage that is used for the stable feeding of horses and dairy cows.[193]

UNITED STATES OF AMERICA.

In no other country are there such opportunities for studying every question concerning lucerne cultivation. The great variations of climate in this country, the varying soils and the different kinds of farming practised, the cultivation of lucerne in dry country and under irrigation give the greatest variety of impressions. Soon after lucerne was introduced into the country the United States Department of Agriculture devoted large sums of money to the placing of the cultivation of this plant upon a sound basis. Trials of different kinds of lucerne were instituted by the Agricultural Experiment Stations in all parts of the country in order to ascertain which varieties were most suitable for the different regions. Seed was brought from every country in the world in which lucerne is grown. Even the cost of expeditions to all parts of Europe and Asia for the collection of seed (chiefly *falcata* types) was no deterrent once it was known that the ordinary *sativa* form could not grow under the climatic conditions of certain districts and that only hybrid forms could be introduced into them.

In 1928 the lucerne area amounted to 11,040,000 acres [194], the second largest in the world. Recently lucerne growing is said to have greatly declined in certain States, a circumstance closely related to the appearance of bacterial wilt. Salmon reports, for example, a decline of 50 per cent in the State of Kansas.[195]

As has already been described elsewhere[196], lucerne came by two roads into the United States. It was brought from Chile to California under the name of " Chilean clover " by the gold seekers, and soon afterwards it was also introduced from Germany into Minnesota. The history of the hybrid lucerne from which Grimm lucerne has originated is fully treated elsewhere. Chilean clover, a *sativa* form, reached the State of Utah later from California. Utah is the only State in the Union in which the name " lucerne " is used to-day instead of the " alfalfa " generally used elsewhere in America.[197] Lucerne then spread from Utah to the States of Colorado and Kansas, where it was first grown along the River Arkansas and in the arid parts of the State. It has become indispensable to-day for both States and represents an important economic factor [198]. The States of Kansas and Nebraska form at present the centre of lucerne cultivation in the United States of America. Both States are in the arid region. Lucerne growing is to be found under all climatic conditions and on all kinds of soils in the States, provided the water tables are favourably situated. The crop is sown on sand, loam, clay, and loess soils, and also on alluvial, detritous and glacial soils.[199] In the southern States of the Union, Alabama, Mississippi, Arkansas and Louisana, lucerne grows especially well on the alluvial soils.

The most favourable conditions are found in the soil of the western mountain States, especially in the alluvial soils of the river valleys. These soils are usually deep and well aerated, and lucerne roots can penetrate very far without any difficulty. The ordinary black North American prairie soils also furnish a good locality for lucerne provided there are not hard clay layers in the subsoil. Among those regions in which success is not always a foregone conclusion are the humid eastern and southern States, those parts of the semi-arid area which cannot always obtain enough water for irrigation purposes (certain parts of the Great Plains and the intermontane country), and to a certain extent also the northern part of the country with its severe winters.[200] In the Great Basin, which may be compared with the North African highlands in the neighbourhood of Sétif, wheat and lucerne are the only plants which can be grown without

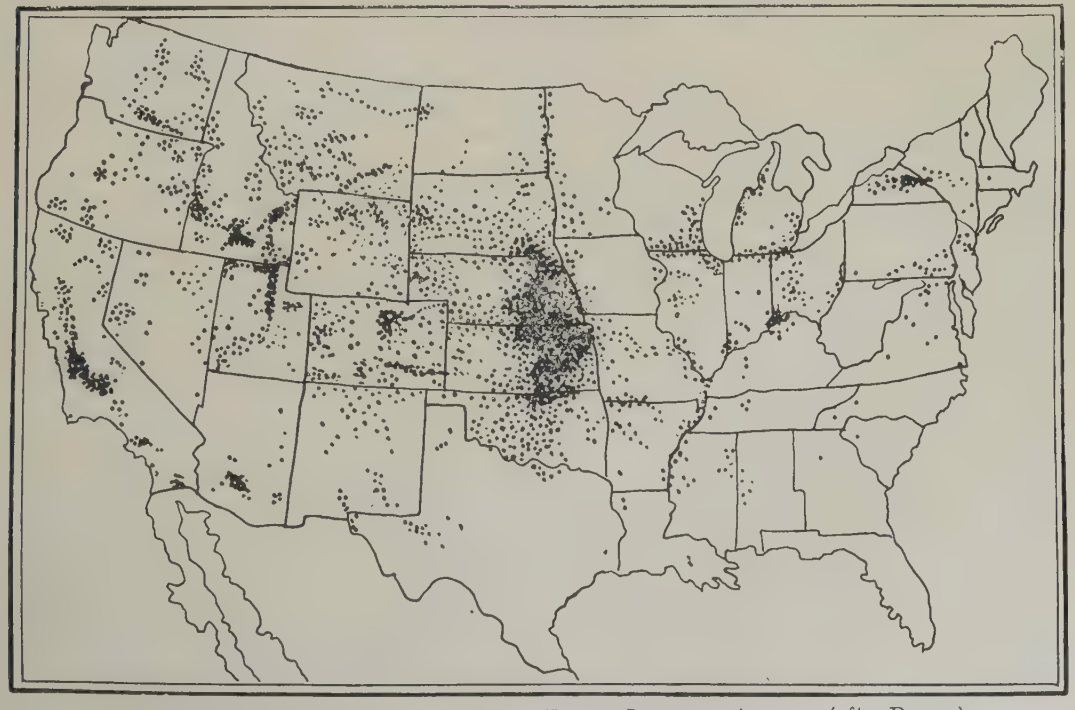


FIG. 15. LUCERNE DISTRIBUTION IN THE UNITED STATES OF AMERICA (after Reeves). Each point represents an area of 2,000 acres.

irrigation.[201] Lucerne has also proved very suitable for the improvement of the sandy soil of the foothills region. Sown down afresh on such soil, it establishes itself where most other crop plants fail and is, therefore, of inestimable value in bringing large areas of virgin soil into cultivation. Unless winterhardy varieties are planted in the dry highlands the crop very soon dies back. Stands which are too dense also have little persistence, as the lack of light tends to suppress the weaker plants. The fact that lucerne is found in localities below sea level (Imperial Valley, California), and on the other hand at a height of 2,400 metres in the Colorado Mts., indicates its wide distribution.[202]

Most of the lucerne seed grown in the States is produced in Utah, Idaho and Arizona, to a smaller extent in Kansas and Nebraska [203]; small quantities of seed come from California, Montana, New Mexico, Minnesota, and North and South Dakota. Eighty to ninety per cent of the American lucerne seed is produced in these eleven States.[204] According to reliable estimates the United States in 1909 produced 7,257.4 tons, in 1924 nearly three times as much (20,865 tons).

The production of commercial seed is for the greater part limited to the district which lies west of the 95th meridian. In the eastern States the cost of production is generally greater than the price of lucerne from the western States. Even in the western States of Kansas and Nebraska and in the semi-arid regions the seed crop frequently fails when precipitation is heavy during the growth period. [205] The occasional seed production districts found in the States east of the 95th meridian (in the humid area) have a definite geological character. The soil here is mainly sandy, and on this a comparatively large amount of seed will nearly always ripen, whilst on the neighbouring field scarcely a single lucerne plant produces ripe seeds. For the production of Grimm lucerne seed only the older lucerne fields are used. The centre of Grimm lucerne seed production is in the State of Montana.[206] Considerable quantities are produced in Idaho, Nebraska, North and South Dakota. Peruvian lucerne seed is chiefly grown in the Yuma Valley in the States of California and Arizona.

Lucerne is sown out for the most part in autumn, as less difficulty is associated with autumn sowing than with spring sowing. There is certainly the danger of the young plants being destroyed by night frosts, but the period of risk is short. Once the lucerne has passed beyond the first leaf stage it is comparatively resistant to cold.[198] Sowing in late spring or in early summer is customary everywhere where it is so dry at other periods that young plants on wide, flat areas are exposed and dried up by high winds.

The persistence of lucerne is very great in the United States, fields 25 and even 45 years old being said to be no rarity. Westgate even reports a field in South Carolina that is said to be 75 years old. In this connection it may be mentioned that fields in which lucerne has grown without resowing for 200 years are reputed to exist in Mexico.

As a rule one can obtain in Wisconsin, for example, three cuts per year, in Texas four or five. The most productive lucerne fields are those of Southern California, a district which, situated below sea level, is free of frost throughout the year. Under these conditions lucerne may be cut as many as eleven times a year. Similar conditions exist in the Valley of the Rio Grande in Texas, where nine cuts are usually obtained. How favourable conditions for lucerne growing are in many parts of the United States is seen from the fact that plants have been found which have produced as many as 369 shoots from one seed. [198]

If the lucerne areas of the North American Continent are compared with the rainfall, very interesting correlations are seen, especially where the forage-growing area is concerned. Lucerne cultivation covers practically the whole Continent, with perceptibly greater density in the vicinity of the 95th meridian. If, on the other hand, the lucerne seed area is considered, it is found that only the western part of the United States is concerned. The few individual seed production districts east of the 95th meridian are, as has already been mentioned, of a definite geological character. Comparison with the rainfall shows that the definitely humid regions play no part in lucerne seed production, and that the seed production areas approach aridity in character. A distinction must probably be made here also between soil types in regard to maintenance and non-maintenance of hereditary vigour.

Oakley and Westover have arranged the lucernes which are grown in the United States into the following groups:

(1) The Common Group includes the purple flowered lucerne, and is composed of a number of strains of quite definite type, grown in the whole of the western part of the United States and in many other countries.

(2) The Turkestan Group, which includes all those lucernes which have developed in Turkestan. They are distinguished from the ordinary lucernes by being somewhat smaller, more spreading and more hairy. No distinctions are made by commercial seedsmen within this group, although the seed from different localities varies considerably.

(3) The Variegated Group, composed of the hybrids of *Medicago sativa* and *M. falcata*. Typical representatives of this group are Grimm, Baltic, Cossack lucerne and the Canadian variegated lucerne.

(4) The Non-hardy Group is comprised of certain varieties which are very susceptible to low temperature. They are characterised by erect growth, they regenerate rapidly and have a long growth period. The Arabian and Peruvian varieties are included in this group.

(5) The Yellow-flowered Group consists of the various forms of *Medicago falcata*. Flower colour and pod form distinguish them clearly from all other groups.

Many other descriptions of lucerne are to be found which describe, however, only the origin of varieties within the United States. Amongst these will be found "dryland alfalfa," the lucerne of the semi-arid districts, which has been grown for several generations without irrigation, has adapted itself to climatic conditions and is therefore very drought resistant.[203] "Hardy alfalfa" is the name of a lucerne growing in a climate which renders the growing of ordinary lucerne impossible—a climate such as is to be found in the Northern States of the Union. To this lucerne belongs, for example, a Montana strain which is grown in the Yellowstone Valley in the vicinity of Billings. Another strain comes from Clearwater in Northern Nebraska[109]. Other strains are often referred to, which are of local importance only. "Kansas grown," "Montana grown" and such like expressions indicate that the seed was harvested in the State in question. Megee[207] speaks of variegated alfalfa, common alfalfa and non-hardy common alfalfa. In the first group he includes Hardigan, Grimm, Cossack, Baltic, Ontario variegated and Ladak lucerne. Michigan common, Montana common, Utah common, Idaho and Dakota common compose the second group, whilst seed from Arizona and Southern California, from Argentina and South Africa compose the non-hardy common alfalfa group. The classification of Ladak lucerne in the variegated alfalfa group is, however, confusing, as Ladak is not a hybrid lucerne, but a form of *M. falcata*.[208]

The Peruvian lucerne area includes the greater part of California (the mountainous parts alone excepted), the southern parts of Arizona, New Mexico, and a strip of territory running along the Gulf of Mexico and the Atlantic shores northwards as far as South Carolina.[209] The salient character of Peruvian lucerne is its long period of growth, which under favourable conditions is absolutely uninterrupted.[210] It is superior therein to Arabian lucerne, which does not, however, become lignified so soon. Arabian lucerne, which is very similar physiologically, is also grown in the South Western States. It develops a great mass of leaves, is very vigorous and possesses great capacity for regeneration. It is, however, short-lived and is therefore commonly used as a subsidiary crop in orchards, where it is required for only two or three years. Like Peruvian lucerne it is highly susceptible to frost and at times, even in the South and South West States, it may be entirely destroyed. In the region adjacent to the Peruvian lucerne area and extending from the Atlantic Ocean as far as the Rocky Mountains lucerne forms are grown which have developed in the States of Kansas, Oklahoma, Texas and others. In the States of Idaho, Nevada, Utah, in the south-western part of Wyoming, in the mountain land of California and large parts of Oregon and Washington, the forms grown other than Grimm lucerne are of scarcely more than local importance.[209] Turkestan lucerne has become established only to a limited extent in North America. It is confined to the non-irrigated regions of New Mexico, Arizona and Colorado, and to the colder and drier regions of North and South Dakota, Wisconsin, and Minnesota. It has been successful only in the semi-arid parts of the Great Plains and in the Columbia Basin. In humid regions it fails without exception[211]; according to the regulations of the Federal Seeds Act Turkestan alfalfa may be imported into the United States only when 10 per cent is dyed with eosin. South African lucerne is subject to a similar regulation. Argentine

lucerne is dyed 10 per cent orange colour. It is not only these strains (on the whole unsuitable for American conditions) which are under obligation to be dyed, but all other foreign lucerne seed. Canadian lucerne is dyed 1 per cent violet, all other foreign lucernes 1 per cent green.[207]

A very promising variety for dry regions is Ladak lucerne. This winterhardy lucerne was not grown in the United States until a few years before the war (1910). It originates in the Northern Mountains of British India, where lucerne is found at a height of as much as 4,500 metres.[145] Only where the growth period is short and dry is it advisable to grow Ladak lucerne, for although it gives a good first cut, it regenerates slowly. Poona lucerne, from the western part of Central India, is said to be still less winterhardy than Peruvian. A characteristic of the Poona lucerne is the root system, lateral roots being almost entirely lacking in the upper part of the tap root.[28] Grimm lucerne is one of the most valuable varieties grown in the United States. The Grimm area is found in unfavourable climates in which it is no longer possible to grow the pure *sativa* forms. Only with the aid of Grimm lucerne, or, more exactly, with the aid of the hybrid character of this lucerne, has it been possible to include wide districts of the United States and adjacent Provinces of Canada in the lucerne area of North America. Its great winterhardiness marks it as one of the most valuable varieties in existence.

As the history of Grimm lucerne is at the same time the history of the old Franconian hybrid lucerne, it is briefly summarized here. Wendelin Grimm, who in 1857 introduced the old Franconian lucerne into Minnesota at Chaska, Carver County, was born in October, 1818, in the northern part of the then Grand Duchy of Baden in the village of Külsheim, situated in an excellent arable district between Wertheim-am-Main and Tauberbischofsheim. Grimm lived at Külsheim until 1857, i.e., until his 40th year. Like so many German farmers he saw in America the land of great possibilities, and determined to emigrate there. He left Germany in May and went to Minnesota, a State in which many of his countrymen before him had already found a new home. He settled in Laketown, where the house he built is still standing, although it has gone out of the family. The old farm comprised only 13 acres, but under Grimm's thrifty management a good living was extracted from it, and he was able in 1876 to move to a better property near the town. He died in December, 1891, at the age of 73 years. At this time his lucerne had just attracted the attention of his neighbours. According to his son the quantity of seed which he brought from Germany was not more than 15 or 20 lb. It was sown down in the spring of 1858, and in the first few winters a large number of plants, which were not adapted to the local climate, died back, but the percentage of survivors was so great that Grimm was able to harvest small quantities of seed every year. Soon his lucerne area grew larger and larger, owing to his fresh sowings, and his neighbours were incited to emulation. They sent for lucerne seed from other States in the Union, but their efforts failed, nearly all the young plants dying off in the first winter. Grimm himself did not live to see the expansion of the lucerne named after him, as it was not until 1905 that the authorities became aware of it. The United States Department of Agriculture then began to test Grimm lucerne, and from this point onwards its value was recognised. The erection of a memorial in honour of Grimm a few years ago shows how highly the Americans appreciate the service rendered by this humble Franconian farmer.

Various observations covering a number of years show that the Grimm lucerne of to-day has no points in common with its initial form, the Old Franconian lucerne. Trials in Baden have shown that Grimm lucerne has quite a different growth rhythm. It is, for example, ordinarily vigorous in the first year of trial, but in the second year deteriorates considerably. Adaptation to climate has materially changed it from the original form.

From the small quantity of seed imported by Wendelin Grimm has been produced a seed which is almost unexampled. Grimm lucerne has become a classic example of the process of selection. Of the large number of hybrid lucernes which are grown in the United States none but Canadian variegated lucerne compares with Grimm in economic importance, whilst Baltic lucerne, a European form, and Cossack, for example, play only a subordinate part. Baltic lucerne may be traced back to the year 1896, when it was obtained by a seedsman at Hartford, South Dakota. It is very similar to Grimm. The description of the Grimm lucerne area holds good also as a general rule for the hybrid lucerne area. Wide sandy areas in the arid region are said to be settled by the hybrid lucernes.

Fig. 16. The Franconian Farmer, Wendelin Grimm (from Stewart [204]).

Cherno lucerne and Cossack are hybrids of Russian origin, derived from single plants which were discovered by Professor V. R. Williams as wild forms in the steppes of the Province of Voronesh in south-eastern Russia. Cossack lucerne has the peculiar characteristic of possessing simultaneously on the same plant pure blue flowers on one stem and pure yellow flowers on another ;[213] in many cases both colours may be seen on the same stem. Cherno lucerne is described as very winterhardy and very productive, the plants are said to be of dark green colour (Cherno =black), but actually the flower colour varies from dark purple to light green with dark purple coloured veins. Both lucernes have distinguished themselves by luxuriant growth : on a single plant for instance as many as 500 stems have been counted. Hansen counted on one Cherno lucerne plant 25,000 well-formed seeds, on another 37,175 seeds, and on Cossack lucerne 31,935 ; the largest number of seeds hitherto reported on one plant is 41,430 on a Cossack lucerne plant. Cherno lucerne was subsequently included amongst Cossack lucerne, as it was not possible to keep the two forms distinct.

Cossack lucerne is very similar to Grimm, being distinguishable only in the higher percentage of yellow colouring in the flowers. Hardigan or Hardy Michigan lucerne, also a hybrid, is characterised by its uniformity, good yield and winterhardiness, being similar as regards yield and winterhardiness to Grimm ; indeed in many trials covering a number of years it has taken the first place. It should also be mentioned that Hardigan lucerne in the more humid parts of the United States is undeniably superior to any other variety in seed production. Hardigan lucerne owes its origin to F. A. Spragg, breeder at the Michigan Agricultural Experiment Station.[207]

Hansen, who was twice sent by the American Government to Siberia in order to collect lucerne seed, brought a large number of types from that country which, although more or less strongly differentiated, all belong to the *falcata* series. The individual areas from which these lucernes come give them their names. Semipalatinsk lucerne was brought from Siberia in 1908, from the dry steppes of the Province of Akmolinsk in Western Siberia, the seeds being collected on the banks of the Irtush River, north of the town of Semipalatinsk. This district has a definitely continental climate with very cold winters and dry, hot summers. The plants attain no great height and are characterized by their upright growth. Later it was introduced again into the United States under the name of " sholteek " and was grown in Dakota, Montana, Wyoming, Colorado and Idaho. The Kirghizian and Russian settlers call *Medicago falcata* " sholteek " in the neighbourhood of Semipalatinsk ; the name is probably a Kirghizian corruption of two Russian words, denoting " yellowish." This word now appears to be used exclusively for *Medicago falcata* in the Semipalatinsk district.[214]

Wild plants from the steppes near Orenburg, situated on the extreme eastern border of European Russia, are the progenitors of Orenburg lucerne. Extreme climatic factors are found in this region, a temperature as high as 37° C is no rare thing in summer, and in winter it occasionally falls as low as 37° below freezing point. The annual precipitation is below the 400 mm. limit. Omsk lucerne, from the immediate neighbourhood of Omsk in the Province of Akmolinsk in Western Siberia, is an erect, very vigorous lucerne, composed of different types. Ob lucerne was collected in the steppes on the River Ob in the Central Siberian Province of Tomsk. The Omsk and Ob lucernes have many characters in common. Samara lucerne, from the steppes of the Volga region in Eastern Russia, is particularly distinguished by a high degree of drought resistance and winterhardiness.

Sibturk lucerne, which has been cultivated now for about fifteen years, is a cross between the Semipalatinsk lucerne and a certain group of Turkestan lucernes bred by Hansen [214a] at the South Dakota Agricultural Experiment Station. Salient characters of this lucerne are its great winterhardiness and reliability of yield, and also its great regenerative power. The flower colour varies considerably, but exhibits a large percentage of yellow shades. The name is formed by a combination of the words " Siberia " and " Turkestan." Hansen's hybrid lucerne No. 2 was also produced in South Dakota : it originated from the Samara lucerne and shows most wonderful variegation in flower colour.

The Gobi Desert lucerne, which belongs to the species *Medicago ruthenica*, is a form which according to Hansen may perhaps become of importance for cultivation. Very extreme degrees of frost, below the freezing point of the mercury, prevail for long periods during

the winter in the Gobi Desert, and there is no covering of snow to protect vegetation; the summer is hot and dry. The natural habitat of this lucerne is in dry sand dunes, where growth in general is poor. In those parts of Mongolia where the temperature in winter drops to as much as 50 degrees below zero, it is one of the most important wild plants used as fodder for horses, camels, cattle and sheep. The reliable yielding properties of the hybrid lucernes and their great winterhardiness induced Hansen to select white-flowering forms with a view to making the plants easily recognizable by purely external characters and to protect them thus from fraudulent practice and adulteration. In the course of breeding it soon became apparent that several of these plants had white seeds also; and in 1921 the white-seeded and white-flowering lucerne was announced; this is generally known to-day as Hansen lucerne and represents a selection from Omsk lucerne. Up to the present the breeding work has not come to a definite conclusion, and it seems very doubtful if the breeder's object is actually possible of attainment.

Besides the varieties already mentioned there are a number of forms such as the Guaranda lucerne, various Mexican varieties, Elche lucerne and Algerian lucerne, which are grown to a small extent. In the last few years a number of new lucerne forms have arisen in the United States, and these, although of local importance only, are very highly esteemed. In a great part of the country the lucerne area has been considerably reduced during the last few years on account of damage caused by bacterial wilt (*Aplanobacter insidiosum* L. McC.). Great resistance to this disease is possessed by a new form produced by the Nebraska College of Agriculture under the name of " Hardistan " lucerne. This lucerne, which also possesses a high degree of winter-hardiness, has probably originated, according to Hecht, from a Turkestan variety. Morphologically, indeed, it has no marked similarity to the typical Turkestan lucerne, resembling more the Nebraska common lucerne. The origin of Hardistan lucerne may be traced to a field in Dawson County.[215] In the State of Michigan Hardigan lucerne takes the first place in all variety trials in which, in addition to winterhardiness, the uniformity of older stands is particularly considered. Seed-setting in this variety is also said to be particularly abundant.[216]

The origin of another as yet little known form, Le Beau lucerne, may be traced back to the year 1886, when Clement Le Beau of Frenchtown, Monroe County, sowed down a lucerne field with seed of unknown origin. Later, he supplied his neighbours, for the most part farmers of French lineage, with seed from this field. Good yielding capacity and propensity for the soil marked this hybrid lucerne as one of the best in the State of Michigan. It should further be mentioned that Le Beau lucerne grows best for seed production on heavy soils, rich in lime and nutrients and having a large humus content.[217]

Recent research in the States of Kansas and Nebraska has drawn attention to a variety which is distinguished by its great resistance to the bacterial wilt so prevalent in these States, and which is further marked by its winterhardiness. The assumption hitherto held that this was a lucerne introduced from Provence can no longer be maintained; it is rather supposed that it may be traced back to Turkestan seed. Salmon[223] proposes the name of " Kaw " for this lucerne. In trials conducted by the Kansas Agricultural Experiment Station it gave evidence of its great winterhardiness, being less injured by low temperatures than Grimm and Ladak lucernes. The yield obtained from this new lucerne form has certainly been very unsatisfactory as yet; it has been considerably less on an average than that of other varieties.

The example of California alone shows of what great economic importance lucerne is for the United States. In the great inland valleys of California, where climatic conditions are very favourable, the lucerne area increases from year to year. In 1921 the value of the lucerne grown in California alone was estimated at approximately 60,000,000 dollars.[218]

CANADA.

Lucerne is grown in districts where the climatic conditions are often still more unfavourable than those of the northern regions of the United States; the lucerne area is nevertheless steadily growing. According to the statistics of the Canadian Yearbook, it increased almost ten-fold in the period 1911-1927, comprising in 1927 914,295 acres. Lucerne is grown in every Province in Canada. It is greatly valued in the arid parts of British Columbia and also in the southern

parts of the Provinces of Alberta and Saskatchewan. It is comprehensible that on account of climatic conditions the growing of lucerne hybrids is of particular importance in Canada. Grimm, Canadian variegated, Cossack and Baltic are the most valuable and the most frequently grown lucerne forms. Morphologically, Canadian variegated and Baltic are so little different from one another and from Grimm lucerne that it is almost impossible to distinguish them. The Canadian variegated lucerne is said to emanate from a French hybrid, but there are no sure proofs of this. The seed production area is situated for the greater part in Western Ontario (Peel County), for which reason people frequently speak of " Ontario variegated." A small district situated near Brooks, in the Province of Alberta, has also attained a position of importance in the production of Canadian lucerne.

As a general rule from two to four cuts of lucerne are obtained in Canada, although in favourable climates the crop may give as many as six cuts.[219] Where there is much precipitation in June and July, e.g. in the Edmonton district, it is frequently difficult to obtain a first cut. In the western States in particular lucerne is the best and most important forage plant. It is sown with and without a cover crop. In Manitoba and in the north-western States lucerne is grown in pure cultures, in Ontario and Quebec almost exclusively under a cover crop. British Columbia takes an intermediate position in this respect.[220] As within the last few years lucerne has been successfully grown over 600 miles north of the American frontier (Vermilion, Alberta), the Canadians estimate that within the next few decades the lucerne area in Canada will be increased a hundred-fold.[204]

AUSTRALIA.

Lucerne growing here is of comparatively recent date. Exact information on the time and the manner of its introduction has not been obtainable. In comparison with the areas already discussed the lucerne area in Australia must still be regarded as very insignificant and, in many parts of the country, still in the experimental stage. Lucerne is found in Queensland, on the Hunter River, and at Tamworth in New South Wales, the last two places representing the principal lucerne districts in Australia. Tamworth lucerne is characterized by its upright growth, its somewhat woody stems, a large tap root, large broad leaves, leafy branchings and vigour.[221] Closely related types are the Hunter River and the Mudgee lucernes, which, however, do not give such good yields as Tamworth, the latter being very highly valued for hay. Of foreign varieties only Peruvian and Arabian lucerne are of any importance. It may perhaps be mentioned that, according to Breakwell,[222] the main root of Arabian lucerne very rapidly becomes rotten in New South Wales, while the new plant growth springs from shoots from the surface of the tap root.

In South Australia Peruvian and Arabian lucernes are grown in addition to Australian strains. The crop thrives best in districts with a semi-arid, subtropical climate, although it may be grown in all parts of Australia. Particular attention must be paid to the plant's water requirements. In the early part of the season one watering for each cutting is sufficient, but later, when temperatures increase, one watering before and one after each cutting will be required on all porous soils ; flooding is considered the best method. Overhead sprinkling is preferred on steep land and for loose and open soil which is liable to be washed away ; whilst running the water in furrows takes its place on land which easily becomes encrusted. On light soils cereals are generally grown the year previous to establishing the lucerne, the seed of which is drilled into the stubble in autumn ; autumn sowings are generally more successful in South Australia than spring sowings. The rate of seeding is determined in accordance with soil moisture conditions and irrigation facilities. On sandy wheat land from 4 lb. to 6 lb. per acre are ample, but for long-duration stands under irrigation, 20 lb. of seed per acre should be used. A nurse crop is used only on sandy land liable to drift, and takes the form of barley (15 lb. per acre) or wheat (20 lb. per acre). The use of farmyard manure is customary ; it is applied at seeding time only when it is well rotted, but in subsequent years no particular importance is attached to its condition. Lucerne is frequently used for pasture, special care being taken to ascertain that the crop is not wet with dew or rain. The best seed is produced in localities where the plants make fairly vigorous growth without artificial watering. Harvesting is done with reaper-threshers having special mouthpieces and sieves.[224]

NEW ZEALAND.

The strain grown almost exclusively here is Marlborough lucerne, emanating from a district in the South Island.

GEOGRAPHICAL DISTRIBUTION OF THE TYPES OF CULTIVATED LUCERNE IN EUROPE, ASIA AND NORTH AFRICA.

In this section I am quoting the deductions worked out by the Lucerne Investigation Division of the Turkestan Plant Breeding Station, Tashkent, although I am unable to agree with their views in every respect. Only the Old World forms are taken into consideration in this review.

One of the largest, if not the largest, collection of lucerne varieties has been accumulated at Tashkent, where some 1,400 samples of *Medicago sativa* L. have been studied for their systematics and their agricultural properties. A series of characters have emerged which are of great significance for plant breeding and for the classification of lucerne.

" These peculiarities are : form of the sprouting plant, form of the adult plant, peculiarities of growing of the root top, size and number and pubescence of the stems, shape and size of stipules, shape and size of leaves, size and colouring of the flowers, shape, size and compactness of the raceme, pubescence, size, colouring and number of turns in the spiral pods, size, shape and colouring of the seeds, winterkilling, maturity, degree of susceptibility to fungous diseases, etc.

On the basis of these peculiarities, in connection with the geographical distribution of different forms of alfalfa, we can state the presence of the following nine types and one subtype. These types are :

1. Mountainous.
2. Khivian.
3. Central Turkestan and Semiryechensk.
4. Khorosan with the Turkmen subtype.
5. Asia Minor.
6. Syrian.
7. Arabian.
8. Tripolitanian.
9. European.

The above-mentioned types are geographically distributed over the following countries :

1. Mountainous type. The mountainous regions of Armenia, Persia, Afghanistan, Central Asia, etc., along the tracts of land 2,000—3,500 m. above sea level, and also at the northern limits of alfalfa-growing.

2. Khivian. The Khivian oasis and Western Semiryechensk, in the other parts of Middle-Asia as an admixture.

3. Central Turkestan (Semiryechensk). The eastern Semiryechensk and the middle parts of Turkestan (districts of Tashkent, Ferghana, Bokhara).

4. Khorosan. North-western Persia, North-western and South-western Afghanistan (Herat, Kandahar), district of Takhta Bazar (the Murgab Valley, Turkmenistan).

5. Asia Minor. All the regions of Asia Minor.

6. Syrian. Palestine and Syria.

7. Arabian. Mesopotamia, South Persia and the coastal region of Baluchistan, Arabia and North Africa.

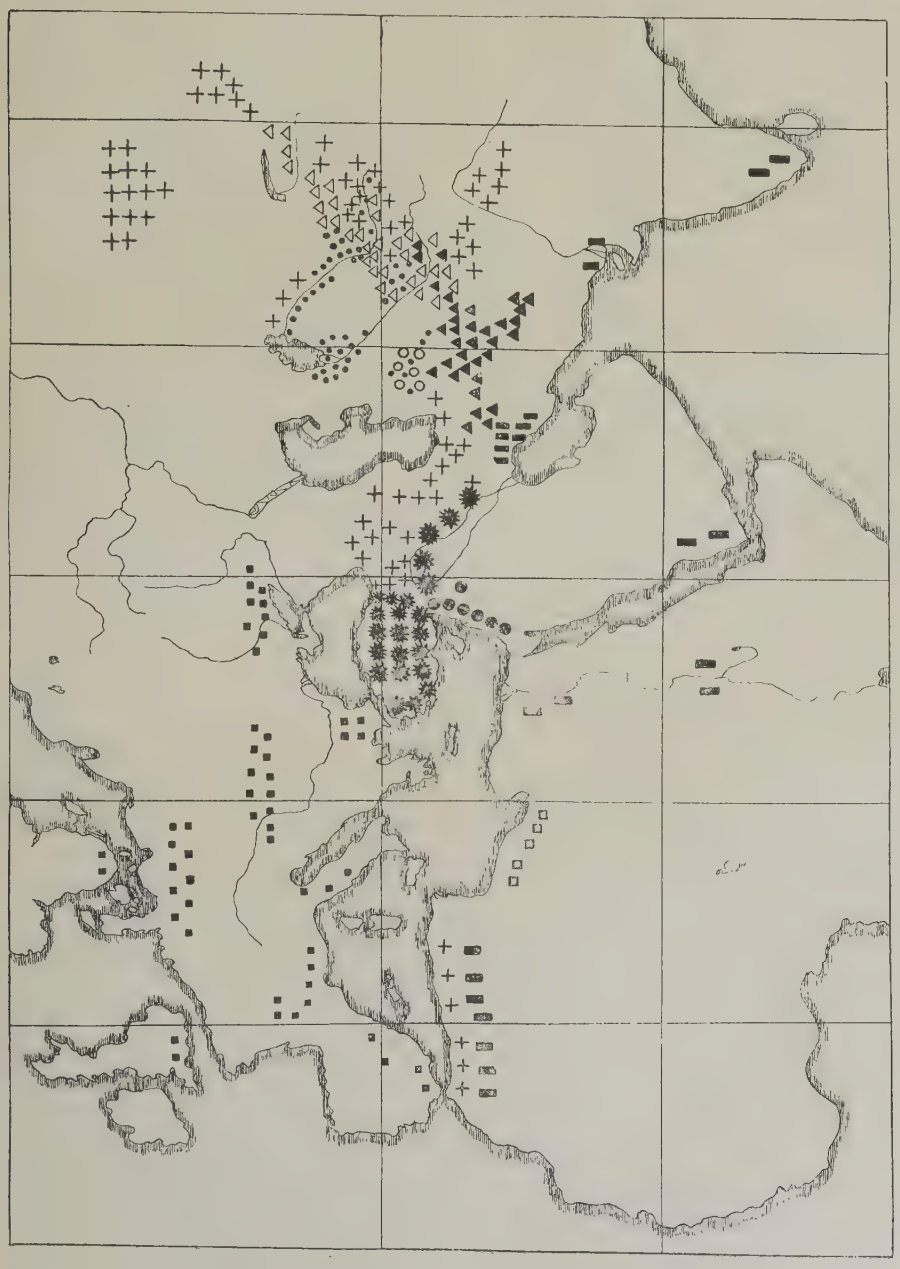
8. Tripolitanian. Tripoli.

9. European. All the countries of Europe.

Most of the described types are concentrated near Western Persia or in the neighbouring regions. This fact may serve as an indication that the centre of formation of the cultivated alfalfas may be situated in Western Persia."

The foregoing statement by Belov[225] gives cause for careful consideration as to whether it is possible to define a European lucerne type. If the hybrid lucerne group is omitted from the

discussion entirely, as indeed has been done by Belov, then Germany, for example, has no part whatever in the classification, because the German lucerne types (including the so-called Iphofen lucerne, which most closely approaches *Medicago sativa* L.) are without exception hybrid lucernes. Even amongst the European *sativa* forms such far-reaching physiological differences exist, as for instance between the Murcia lucerne of the south of Spain and Hungarian lucerne, that their inclusion in one and the same group cannot be justified.



Geographical distribution of cultivated M. sativa forms (after Belov)

FIG. 17.

GEOGRAPHICAL DISTRIBUTION OF PLANT SHAPE IN EUROPE, ASIA AND NORTH AFRICA.

The habit of the forms found in the various areas exhibits quite definite relationships to the ecological factors present. The thermophilic and heliophilic characters which are after-effects of the plant's original habitat stamp the habit of this continental constitution[226] in every locality where it is grown. Where the character of the country approaches that of the Turanian lucerne area and where similar intensities of light and heat are found as in Turania, we encounter erect types which may equally well be defined as "light forms." In lucerne areas of greater altitude and in localities where these conditions are lacking or are present for too short a period, more widely spreading forms are found. Alterations in the intensity of light and heat which are adverse to the primeval requisites of lucerne lead to geotropic movements, and these may have so great an effect that the aerial organs of the plant remain outspread.

"In the geographical distribution of different peculiarities of cultivated alfalfas definite regularities may be noted, including chiefly :

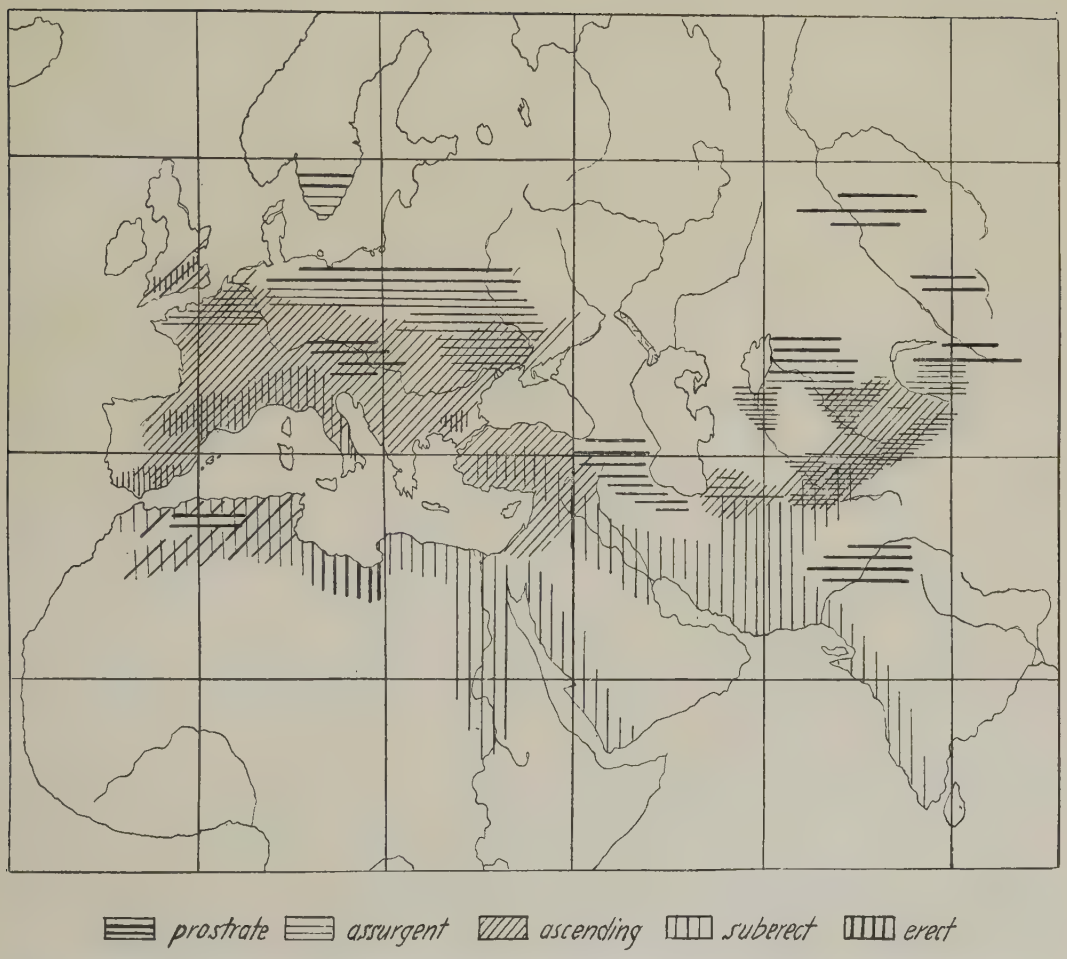
(a) the form of the plant changes from erect to prostrate in the direction from south to north and from lower regions to higher (in regard to the sea level) ;

(b) the degree of sprouting decreases from south to north and from lower regions to higher ;

(c) the length of the vegetation period decreases from south to north and from lower regions to higher ;

(d) the most subject to fungous diseases is the Khorosan type and the least susceptible are the Arabian and Tripolitanian.

The study of cultivated alfalfa of all the countries of the world, conducted on a large scale, has given numerous data which partly explain the course of evolution and distribution of cultivated alfalfa, and may serve also for estimating the agricultural value of different types."



Geographical distribution of the plant shape in cultivated alfalfa after Belov.

FIG. 18.

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